

Instrumentation and Techniques for Vehicle Refueling Emissions Measurement

1. Scope—This SAE Recommended Practice describes a procedure for measuring the hydrocarbon emissions occurring during the refueling of passenger cars and light trucks. It can be used as a method for investigating the effects of temperatures, fuel characteristics, etc., on refueling emissions in the laboratory. It also can be used to determine the effectiveness of evaporative emissions control systems to control refueling emissions. For this latter use, standard temperatures, fuel volatility, and fuel quantities are specified.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J171—Measurement of Fuel Evaporative Emissions from Gasoline Powered Passenger Cars and Light Trucks Using the Enclosure Technique

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 86—Method for Distillation of Petroleum Products

ASTM D 323—Test Method for Vapor Pressure of Petroleum Products (Reid Method)

ASTM D 3343—Method for Estimation of Hydrogen Content of Aviation Fuels

2.1.3 FEDERAL REGISTER PUBLICATIONS—Available from U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20480.

40 CFR Part 86—Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Refueling Emissions Regulations for Light-Duty Vehicles and Light-Duty Trucks

40 CFR Part 88—Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Refueling Emissions Regulations for Light-Duty Vehicles and Light-Duty Trucks

40 CFR Part 600—Control of Air Pollution From New Motor Vehicles and New Motor Vehicle Engines; Refueling Emissions Regulations for Light-Duty Vehicles and Light-Duty Trucks

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3. **General Discussion**—Refueling losses are made up of the following individual losses:

- a. Displaced fuel tank vapor
- b. Entrained fuel droplets in the displaced vapor
- c. Liquid spillage
- d. Nozzle drip during insertion and removal from the filler neck

Experience has shown that displaced vapor normally is 90% or more of the total loss. The amount of displaced vapor is known to be affected by a number of factors, particularly dispensed fuel temperature, Reid vapor pressure, and the degree to which dispensed fuel and displaced vapor come into contact.

The measurement facility described in this document includes a sealed enclosure or SHED (SHED=Sealed Housing for Evaporative Determinations). This SHED is identical to that described in SAE J171, except for the minimum length specified and that a refueling hose and nozzle has been added. The hydrocarbon measuring instrumentation is identical to that of SAE J171. This technique is used to measure the total evaporative losses for the four sources listed previously.

The document includes the following sections:

4. Test Fuel
5. Test Facilities and Equipment
6. Measurement Method
7. Information and Data to be Recorded

4. **Test Fuel**

4.1 **Standard Conditions**—This test applies to all vehicle fuels. For a standard test, however, a fuel should have a Reid Vapor Pressure (RVP) of $62 \text{ kPa} \pm 2 \text{ kPa}$ ($9.0 \text{ psi} \pm 0.3 \text{ psi}$). To describe the fuel being used adequately, it should be inspected for the properties in Table 1:

TABLE 1—PROPERTIES

Property	ASTM Test Method
Distillation	D 86
IBP	—
5%	—
10%	—
15%	—
20%	—
30%	—
40%	—
50%	—
90%	—
FBP	—
Reid vapor pressure, Pa (psi)	D 323
Hydrogen-Carbon ratio ⁽¹⁾	D 3343

1. The hydrogen-carbon (H/C) ratio is required for the calculation of losses using the enclosure method. The H/C ratio will be different for vapor losses as compared to liquid losses. Therefore, the H/C ratio should be measured for both condensed vapor and for the test fuel. Judgment should be used in interpolating between the two values for individual tests.

The fuel should not be reused for subsequent refueling emission tests.

4.2 Nonstandard Fuel—A nonstandard test fuel may be used if the purpose of the test is to examine the effect of the fuel properties on refueling emissions. If a nonstandard test fuel is used, the RVP shall be stated along with the test results.

If methanol or ethanol blends are used, the analytical techniques should be reviewed (the sensitivity of a flame ionization type detector to methanol and ethanol is significantly reduced).

4.3 Fuel Sampling—A sample of test fuel for laboratory inspection should be taken from the source at the start of the test. A 1.0 L (1 qt) container, prechilled to 4 °C (40 °F) should be used. It should be bottom filled to overflow and then poured out to 80% capacity. The container should be tightly sealed immediately after filling and stored at 4 °C (40 °F) or less until fuel inspection tests are made. Alternative sampling procedures may be substituted, but care must be exercised with any sampling procedure to prevent the loss of volatile constituents from the fuel during either sampling or storage.

5. Test Facilities and Equipment—Provisions must be made for controlling the ambient conditions in the enclosure, draining the fuel tank, heating the residual fuel, and performing the refueling operation.

5.1 Ambient—The ambient temperature within the enclosure must be maintained within the range of 27 °C ± 1.7 °C (80 °F ± 3.0 °F).

5.2 Fuel Tank Preparation—Facilities and safeguards must be provided for draining vehicle fuel tanks. The work area must be well ventilated. Drain connectors and containers must be grounded to the vehicle tank. Drain the tank through installed fuel tank drains or other suitable method. The intent is to remove all usable fuel and leave the unusable fuel, thus providing a standard repeatable empty-tank condition. For standard conditions, an amount of fuel equal to 10% of the tank capacity should then be placed in the tank. Affix fuel cap to filler pipe and tighten prior to placing the vehicle in the enclosure.

5.3 Fuel System Preparation—The entire fuel system should be inspected visually for liquid leakage or seepage. A pressure test of fuel tank assembly, filler pipe, fuel lines, vapor lines, and other components (14.4 psig ± 0.5psig for 20 min) should be made to insure the integrity of the fuel system.

5.4 Evaporative Canister Preparation—Vehicle canisters should be loaded and purged according to CFR 40, Part 86, 88, and 600 dated 01/94 prior to the refueling test.

5.5 Thermocouples—Thermocouples should be of Iron Constantan (type J) and should be provided for:

- a. Residual fuel in tank
- b. Vapor space in tank
- c. Fuel in conditioner
- d. Dispensed fuel (thermocouple in nozzle)
- e. Displaced vapor (located either on nozzle or on filler neck)
- f,g. Enclosure (see 6.1)

The thermocouples, particularly those used for vapor, should have fast response. A multichannel potentiometer-type recorder or data logger with 0.5 °C (1 °F) accuracy and a time resolution of 1 s should be used.

- 5.6 Tank Fuel Heating**—The vehicle should be stored (soaked) at an elevated temperature of $27\text{ }^{\circ}\text{C} \pm 1.7\text{ }^{\circ}\text{C}$ ($80\text{ }^{\circ}\text{F} \pm 3.0\text{ }^{\circ}\text{F}$) to heat the fuel tank prior to the refueling operation. This soak period should be a minimum of 6 h and a maximum of 24 h. A possible alternative to the total vehicle soak could be the use of an electric heating pad. This pad should cover 50% or more of the area wetted by the test fuel. A 2000 W heating pad with a variable voltage transformer to regulate heat output should be adequate for most vehicles. Alternative heating methods may be used on vehicles of unusual configuration or, if necessary, to comply with local laboratory safety practices. All methods should avoid hot spots on the tank wetted surface which could cause local overheating of the fuel. Care must be exercised to not apply heat to the vapor in the tank above the liquid fuel. With proper heating of the tank, vapor temperature will not exceed liquid temperature by more than $3\text{ }^{\circ}\text{C}$ ($6\text{ }^{\circ}\text{F}$). The standard temperature for residual fuel in the tank should be $27\text{ }^{\circ}\text{C} \pm 1.7\text{ }^{\circ}\text{C}$ ($80\text{ }^{\circ}\text{F} \pm 3.0\text{ }^{\circ}\text{F}$) at the start of the test.
- 5.7 Fuel Conditioning and Supply Facility**—The refueling facility consists of a fuel tank with temperature control equipment, service station type dispensing pump, meter, hose, and nozzle. Only the hose and nozzle are inside the enclosure. The hose shall intersect the enclosure wall below the level of the vehicle fuel tank filler; the seal at the intersection of the base and the wall shall be gas-tight. Sealed arm holes with gloves shall extend inside the SHED and permit the operator to perform fueling operations from outside the SHED. The amount of fuel trapped in the hose and other piping outside of the temperature control unit should be minimized. Figure 1 shows a typical fuel conditioning unit.

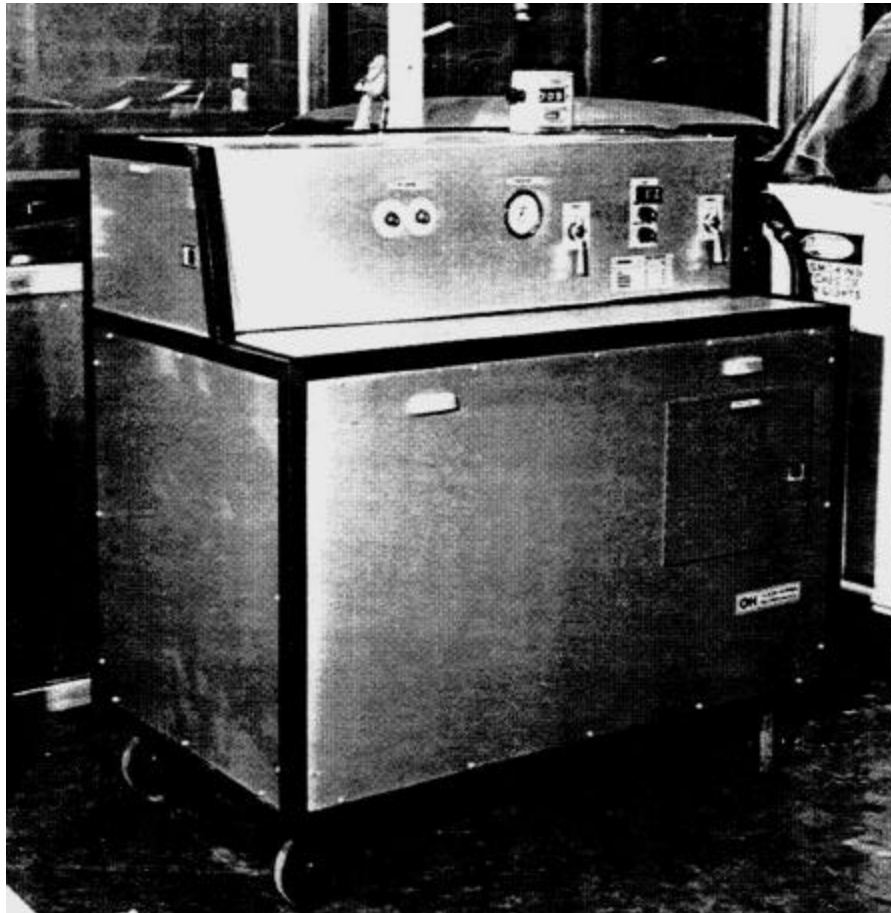


FIGURE 1—FUEL CONDITIONING UNIT

The system must be capable of delivering fuel at the desired test temperature and flow rate. The temperature of the fuel stored in the unit and to be delivered during the test is $19.4\text{ }^{\circ}\text{C} \pm 0.8\text{ }^{\circ}\text{C}$ ($67\text{ }^{\circ}\text{F} \pm 1.5\text{ }^{\circ}\text{F}$). The standard flow rate should be between $15.9\text{ to }37.1\text{ L/min} \pm 1.1\text{ L/min}$ ($4.2\text{ to }9.8\text{ gal/min} \pm 0.3\text{ gal/min}$) during the test.

6. **Measurement Method**—The car enclosure method provides for sealing the vehicle in an enclosure during the test. Emissions are determined from the changes in the hydrocarbon concentrations in the enclosure. This method produces a single measurement of refueling losses from all sources.
- 6.1 **Equipment Requirements**—An enclosure with internal dimensions of $3.1 \times 6.7 \times 2.6\text{ m}$ high ($10 \times 22 \times 8.5\text{ ft}$ high) has been found convenient for testing most United States passenger cars. The foregoing dimensions may be adjusted to accommodate different sized vehicles without significantly affecting the test results. The enclosure door must allow entry of the maximum sized vehicle. Door sealing may be accomplished by a resilient gasket, an inflatable seal, or a pressure sealing zipper if a flexible door is used. Interior surfaces must be impermeable to hydrocarbons. Permeable materials may be covered with a polyvinyl fluoride¹ sheet of approximately 0.15 mm (0.006 in) thickness. One wall, door, or ceiling should be of flexible material such as 0.15 mm (0.006 in) polyvinyl fluoride sheet to provide a safety “blow-out” panel, and to allow for minor temperature changes of the contained gas without excessive “breathing.” The enclosure should have a window located so that the instrument operator can observe the refueling operation. Electrical ground connections must be provided between any metal parts of the enclosure and the dispensing nozzle. A ground lead and a clip must be provided for grounding any part of the vehicle coming in contact with the fuel or fuel nozzle (rear bumper, fuel filler tube, and fuel tank).

Figure 2 shows two different enclosure designs.

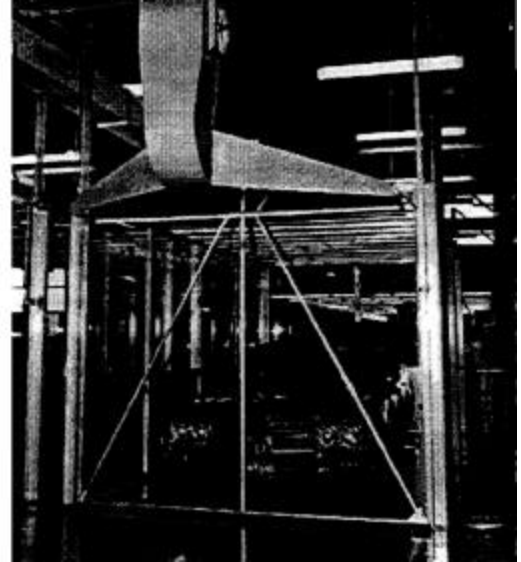
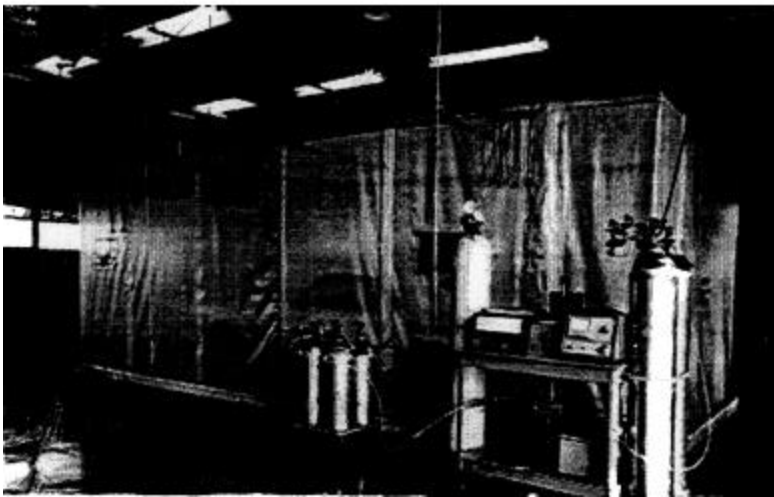


FIGURE 2—DIFFERENT ENCLOSURE DESIGNS

1. "Tedlar" or equivalent.