SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J900

REAF. MAR95

Issued 1964-06
Reaffirmed 1995-03

Superseding J900 AUG85

Submitted for recognition as an American National Standard

CRANKCASE EMISSION CONTROL TEST CODE

Foreword—This reaffirmed document has been changed only to reflect the new SAE Technical Standards Board format.

1. ***Scope***—The purpose of this SAE Standard is to provide standard test procedures for crankcase emission control systems and/or devices. The procedures included are for determining:

a. The flow rate of the blowby of an engine
b. The flow rates through the crankcase emission control system inlet and outlet

This code is written to cover crankcase emission control systems which are designed to reduce the emission of engine blowby gases to the atmosphere. The code includes the following sections:

3. Definitions and Terminology
4. Test Equipment
5. Test Procedures
6. Information and Data to be Recorded
7. Data Analysis
8. Presentation of Information and Data

2. ***References***—There are no referenced publications specified herein.

3. ***Definitions and Terminology***—The following definitions apply to the terms indicated as they are used in this code.

3.1 **Engine**—Internal combustion engines in which the crankcase is not a principal part of the induction system.

3.2 **Crankcase**—The volume within an engine which is connected to the oil sump section by internal passages through which gases can flow.

3.3 **Blowby**—Those gases which enter the crankcase as leakage past the piston rings and/or the intake and exhaust valve mechanisms.

3.4 **Fresh Air**—Any outside air introduced into the crankcase, generally to aid in ventilation (purging of blowby gases from the crankcase).

3.5 Crankcase Emission Control System—A system of passages designed to convey gases from and/or to the crankcase of an engine. The system may or may not include means to regulate the flow(s).

3.5.1 SYSTEM INLET—Any passage connecting the crankcase to the atmosphere; which passage is provided for the purpose of admitting fresh air into the crankcase. It may, under some conditions, allow the discharge of blowby gases from the crankcase.

3.5.2 SYSTEM OUTLET—Any passages from the crankcase which are designed to carry gases to points other than the atmosphere.

4. Test Equipment

4.1 Precautions

4.1.1 The mixture being measured is composed of air, fuel, oil, and combustion products, in varying proportions. Any or all of these can be harmful to measuring equipment either by fouling and/or by long-term corrosion or erosion effects, thus reducing instrument accuracy. For these reasons, it is necessary to use rigid maintenance practices to preserve instrument accuracy. In addition, care must be taken to avoid condensing the vapors that are present in the mixture being measured. In some cases, oil drops may be present in the crankcase gases being measured and it may be necessary to employ an oil separator to avoid erroneous flow readings due to oil accumulations in the flowmeter.

4.1.2 The flow restrictions of the measurement equipment can greatly affect the volume of flow. For this reason, it is necessary to use some means such as a make-up blower to compensate for the restrictive effect.

4.1.3 The pressures created by actual vehicle movement and engine operation, as well as the system design, will affect flow rates on many types of emission control systems. Therefore, it will be necessary for laboratory tests to simulate the vehicle insofar as it affects the system.

4.2 Flow Measurement Instrumentation—A suitable meter such as a rotometer, viscous flow meter, flow orifice, venturi, or integrating gas meter should be used. Meter accuracy should be within ±5%.

4.3 Pressure Measurement Instrumentation—Suitable manometers or pressure gages should be used. Accuracy should be within ±5%.

4.4 Temperature Measurement Instrumentation—A suitable instrument such as a liquid filled, gas filled, or resistance thermometer, or a thermocouple may be used. Accuracy must be within ±1 °C.

4.5 Vehicle Test—Road—For vehicle tests, it is convenient to mount the flow, pressure, and temperature measuring instruments as well as the make-up blower in a single instrument case for ease of use by the observer. In addition to these instruments, it is desirable to measure engine manifold vacuum (pressure gage) and engine speed (tachometer), and it may be necessary to provide means to measure actual vehicle speed.

4.6 Vehicle or Engine Test—Dynamometer—In addition to measurements made in vehicles during road operation, it may be useful or necessary to simulate vehicle operation under laboratory conditions. The utility of such measurements is entirely dependent upon the ability to simulate those road conditions which may influence the performance of the particular crankcase emission control system under test or the quantity of blowby created by the engine. Most chassis dynamometers are custom installations and any particular installation may or may not have accessories needed for pertinent road simulation. These might include means for creating air movement past the vehicle and engine at road velocities and for accurate reproduction and control of power requirements including deceleration. Most engine dynamometer installations can reproduce road loads but few can simulate air movements, which may prohibit their use.

4.7 Flow Bench Equipment—Figure 1 shows typical flow bench equipment. In addition to flow, pressure, and temperature instruments, means must be provided to supply the air flow quantity at the pressures required.

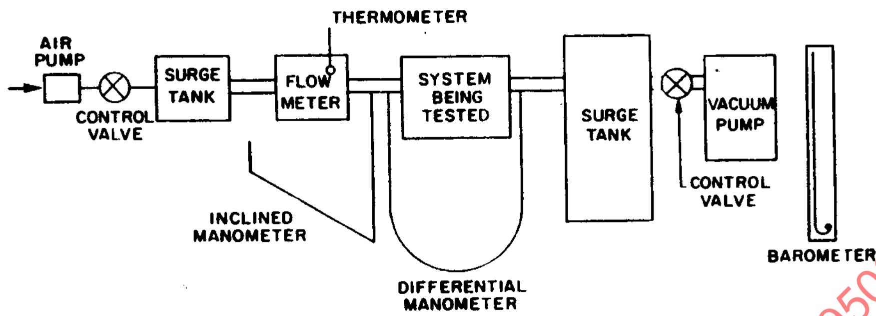

FIGURE 1—BASIC LABORATORY FLOW BENCH EQUIPMENT

5. Test Procedures

5.1 Blowby—Measurements are made at the desired conditions of engine or vehicle speed and load. Seal all crankcase openings and system inlet and outlet passages except the normal major outlet. The rate of gases flowing through the remaining opening will be measured (see Figure 2). Among the openings to be sealed are the oil filler pipe, the dipstick opening, and, in some cases, the fuel pump breather. Since, on many engines, leaks are present around rocker arm cover gaskets, oil pan gaskets, and other seals, it will be necessary, if accuracy is required, to account for the escape of blowby through them or to reduce the error by keeping the crankcase at ambient pressure with a blower installed as illustrated in Figure 3.

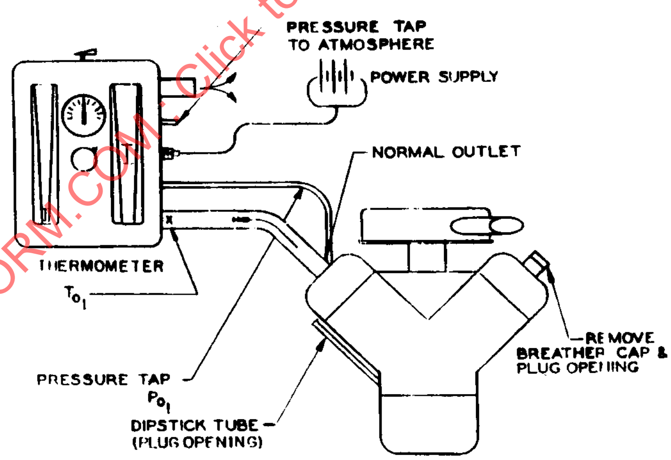

FIGURE 2—TYPICAL ARRANGEMENT FOR MEASURING BLOWBY RATE

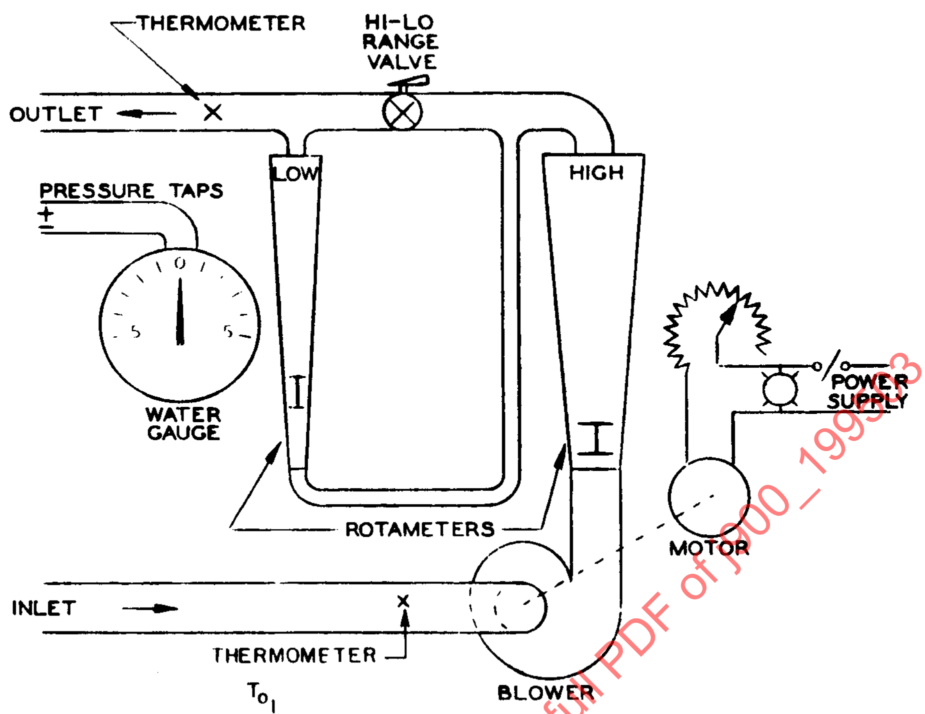

FIGURE 3—SCHEMATIC OF TYPICAL TWO ROTOMETER BALANCING TYPE INSTRUMENT

5.2 Crankcase Emission Control System Flow Rates—For the purpose of this code, the outlet flow rate is defined as follows in Equation 1[1]:

$$\text{Inlet flow rate} + \text{Blowby flow rate} = \text{Outlet flow rate}^1 \quad \text{(Eq. 1)}$$

If only two of the three rates can be measured directly, the other can be obtained by difference; however, in the interest of accuracy, it may be necessary to determine the smallest of these quantities by the pressure differential method given in footnote 1.

Figure 4 illustrates an installation of a control system where it is difficult to measure the fresh air flow into the crankcase directly and relatively easy to measure the outlet flow.

Figure 5 shows a different type of system installed that makes outlet flow difficult to measure, since the control valve is inserted directly into the rocker arm cover. The fresh air inflow is measurable through the passage between the breather cap and the crankcase, or through the hose connecting the carburetor air cleaner and the oil filler cap.

1. This follows from the law of conservation of mass, that is, "mass flow in" plus "blowby mass flow" equals "mass flow out."

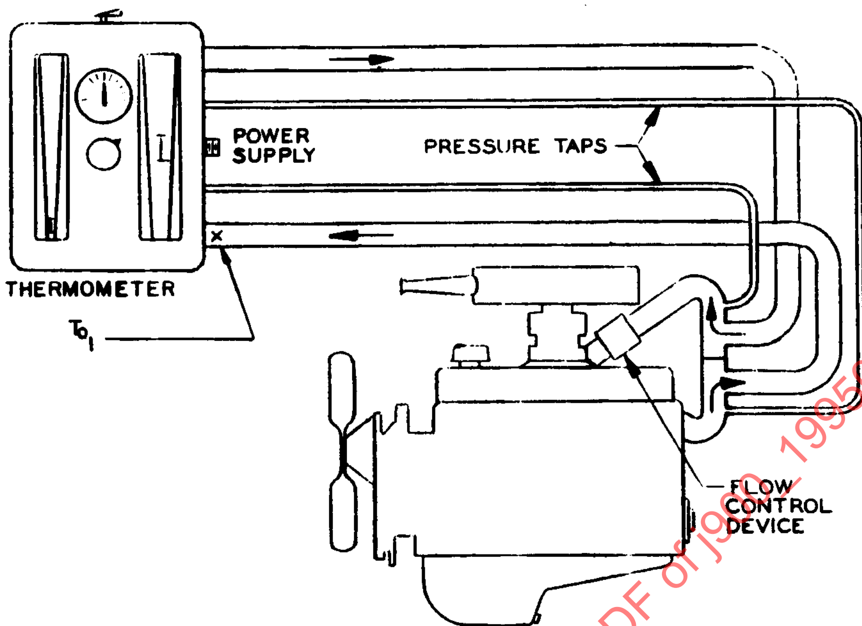

FIGURE 4—TYPICAL INSTALLATION FOR MEASURING SYSTEM OUTFLOW

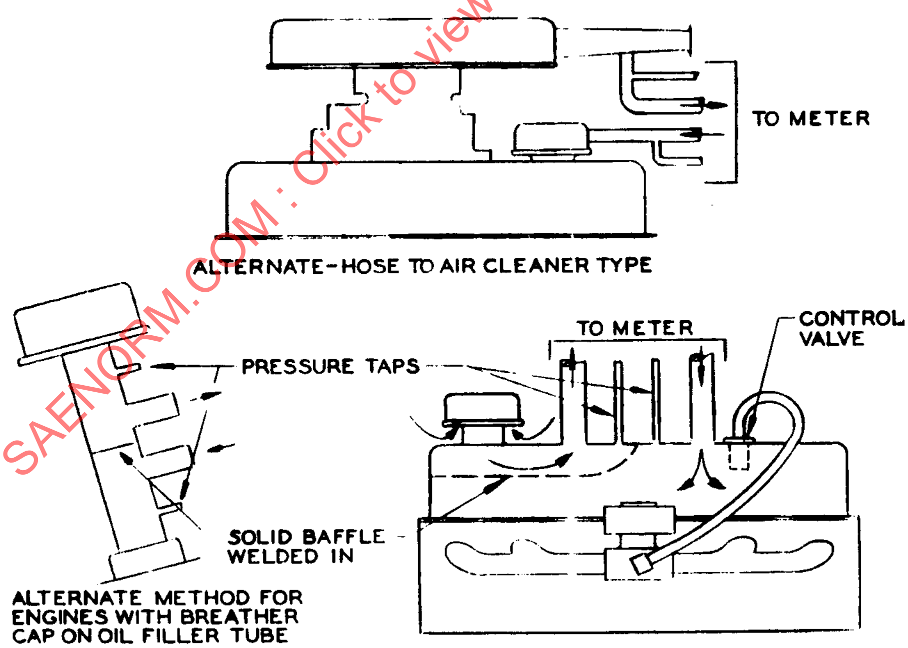

FIGURE 5—TYPICAL METHOD OF MEASURING FRESH AIR INLET RATE

Expressed mathematically, this is:

$$Q_{I\rho I} + Q_{BB\rho BB} = Q_{OUT\rho OUT} \quad \text{(Eq. 2)}$$

Then, if all of these densities (ρ) are identical:

$$Q_I + Q_{BB} = Q_{OUT} \quad \text{(Eq. 3)}$$

Therefore, all volume flow rates, expressed in L/s, must be reported at the same temperature and pressure for this to hold true.

Flow rates through the oil filler cap in Figure 5 and through the control valve in Figure 4 may be estimated by measuring the inlet and outlet pressures across them during vehicle operation and then reproducing these pressures in the laboratory where flow can be measured.

5.2.1 MEASUREMENT AT SYSTEM OUTLET—Flow rate shall be measured on the engine for which the system was designed by installing the equipment such as shown in Figure 3 to a typical system outlet shown in Figure 4. With systems incorporating a modulating device, the flow rate measuring equipment should be used on the inlet side of the device (see Figure 4). If the capacity of the emission control system is influenced by the blowby rate of the engine, air may be added to the crankcase at such a location and manner to produce a volume of flow through the system equivalent to the desired blowby rate.

5.2.2 MEASUREMENT AT SYSTEM INLET—If the flow rate at the system inlet will not be materially affected by the installation of measuring equipment, its value may be measured directly. Flow rate shall be measured on the engine for which the system was designed by installing the equipment such as is shown in Figure 3 to a typical system inlet as shown in Figure 5.

The flow may be positive (inward) or negative (outward).

6. Information and Data to be Recorded

6.1 Information

6.1.1 GENERAL

a. Laboratory performing test
b. Date of test
c. Description of test equipment, including method of power absorption

6.1.2 VEHICLE DESCRIPTION

a. Manufacturer
b. Model year
c. Body style
d. Transmission

6.1.3 ENGINE DESCRIPTION

a. Manufacturer
b. Configuration—type and number of cylinders
c. Displacement
d. Carburetor—number of venturies
e. Condition—New________ or Hours________ or Kilometers________

6.1.4 CRANKCASE VENTILATION SYSTEM DESCRIPTION

a. Manufacturer
b. Part or system identification number
c. Principle of operation

6.2 Data

6.2.1 DATA TO BE RECORDED IN ALL CASES

a. Observed flow rate(s)
b. Observed gas temperature(s) at the measuring instrument
c. Ambient pressure
d. Ambient temperature
e. One or more of the following:

   1. Engine or vehicle speed
   2. Engine or vehicle load
   3. Engine intake manifold vacuum
   4. Crankcase pressure

6.2.2 DATA TO BE RECORDED WHEN APPLICABLE

a. Gas pressure(s) at the measuring instrument(s)
b. Gas temperature(s) in the system, for example, system inlet, system outlet, at control device, etc.
c. Gas pressure(s) in the system, for example, system inlet, system outlet, at control device, etc.
d. Engine oil temperature
e. Engine water temperature

7. Data Analysis—For purposes of uniformity, flow rates should be reported at 65 °C and 100 kPa. In order to report flow rates at these conditions it may be necessary to perform one or more of the following computations:

a. A meter correction to convert an observed flow meter reading to actual flow rate through the meter.
b. A calculation of the volume flow rate in a portion of the system which is of interest and in which the temperature and/or pressure are different from the existing at the meter.
c. A prediction of the flow rate at temperature and pressure conditions other than those at which observed measurements were made.

For engines and/or crankcase emission control systems which exhibit a gas temperature and/or pressure in the outlet portion of the crankcase emission control system (for example, control valve) significantly different from 65 °C and/or 100 kPa, the flow rate shall be measured at or predicted at the different temperature and/or pressure.

7.1 Meter Correction—Flow meters are calibrated at specific temperatures and pressures which may not prevail at the time an observation is made. Any observed flow reading must be corrected to a value corresponding with the actual temperature and pressure existing at the flow meter.

This correction will depend upon the particular flow measuring instrument being used. As an example, for an orifice meter or rotometer, the observed reading may be corrected by the following general relationship:

$$Q_{a1} = Q_o\sqrt{\frac{P_c T_{01}}{T_c P_{01}}} \quad \text{(Eq. 4)}$$

where:

Q_{a1} = Actual volumetric flow rate through the meter at the observed temperature and pressure at the meter inlet, mm^3/min
Q_o = Observed meter reading
P_{o1} = Observed absolute gas pressure at the meter entrance
P_c = Absolute gas pressure corresponding with the gas density upon which the flow meter calibration is based
T_{o1} = Observed absolute gas temperature (degrees K) at the meter entrance
T_c = Absolute gas temperature (degrees K) corresponding with the gas density upon which the flow meter calibration is based

Equation 4 is typical for rotometers; however, exceptions have been noted. For these exceptions and for other types of flow measuring instruments, the manufacturer's recommendations should be followed.

7.2 Flow Rate Adjustments—If it is desired to determine the volume flow rate at some other position of interest in the system with the same mass flow rate as through the meter, use Equation 5:

$$Q_{a2} = Q_{a1}\frac{P_{01}T_{02}}{T_{01}P_{02}} \quad \text{(Eq. 5)}$$

where:

Q_{a2} = Actual volumetric flow rate at the position of interest at the observed temperature (T_{o2}) and pressure (P_{o2}) at this position

7.3 Flow Rate Predictions—As indicated in Section 7, flow rates are normally to be reported at 65 °C and 100 kPa (or at such other conditions shown by experience to be more typical of a specific engine and/or crankcase emission control system).

Since it may not be possible to make flow measurements and to operate the system so that the temperature and pressure at the flow controlling portion of the system are 65 °C and 100 kPa, predictions as to the volume flow rate at those conditions must be made.

These predictions must be made in accord with the flow characteristics of the flow controlling portion of the system. For a fixed orifice, or for a variable orifice valve in which the orifice size is essentially uninfluenced by gas temperature or pressure, Equation 6 may be used for this prediction with an accuracy consistent with the accuracy of the measurements being made [2].

$$Q_p = Q_{a2}\sqrt{\frac{P_{02}T_p}{T_{02}P_p}} \quad \text{(Eq. 6)}$$

where:

Q_p = Predicted volumetric flow rate at T_p and P_p
T_p and P_p = 338 K absolute temperature (65 °C) and 100 kPa absolute pressure or other typical conditions described previously

Certain crankcase emission control systems (such as a diaphragm-type pressure regulator) are so designed as to have flow characteristics significantly affected by crankcase temperatures and pressures. For such systems, the observed flow rates can only be adjusted, as in 7.2, to the actual gas temperatures and pressures existing at the control valve. Flow rates at other temperature and pressure conditions cannot be predicted as previously outlined. It is recommended that for such systems the outlet flow rate be determined by summation of the blowby rate and inlet flow rate as discussed in 5.2.

8. *Presentation of Information and Data*—The information and data are to be presented as follows:

a. The description of the system including its installation on the engine. A schematic diagram showing the important components and their points of connections should be included.
b. The scope of the test being carried out.
c. The test procedure followed.
d. The findings and conclusions of the test.

The test data obtained should be listed, preferably in tabular form, in a manner that will make clear the test sequence followed as well as the calculation procedure followed. The final results should be presented, preferably in graphic form as illustrated in Figures 6 and 7, in a manner that will describe the characteristics of the system.

All flow data shall be presented in L/s at 65 °C and 100 kPa when practical. If other conditions are selected as permitted in Section 7 and 7.3, the temperature and pressure shall be reported with the flow data and the reason for the selection shall be given.

2. For sonic flows, Equation 6 is not accurate, but for most cases it is suitable as an empirical equation and should be used.