(R) Test Method for Measuring Performance of Engine Cooling Fans

1. **Scope**—This SAE recommended Practice is intended for use in testing and evaluating the approximate performance of engine cooling fans. This performance would include flow, pressure, and power. This flow and pressure information would then be used to estimate the engine cooling performance. This power consumption would then be used to estimate net engine power per SAE J1349. The procedure also provides a general description of equipment necessary to measure the approximate fan performance.

The test conditions in the procedure generally will not match those of the installation for which cooling and fuel consumption information is desired. The performance of a given fan depends on the geometric details of the installation, including the shroud and its clearance. These details should be duplicated in the test setup if accurate performance measurement is expected. The performance at a given air density and speed also depend on the volumetric flow rate, or the pressure rise across the fan, since these two parameters are mutually dependent. These parameters depend on the pressure drop across the radiator core and the ram pressure due to vehicle motion. For these reasons, the test procedure should be recognized as providing only an approximate measure of installed fan performance.

Although the test procedure is based on running the fan with a motoring dynamometer, the actual installation can be used as a test fixture if an accurate torque meter is available. In this case, the same qualifications discussed apply. Finally, for the effect of a fan clutch in reducing fan use and power consumption, which is not a part of this procedure, refer to SAE J1342.

1.1 **Purpose**—This document provides a recommended test procedure for measuring and comparing the performance of fans over a range of pressure and speeds. The resulting performance data are intended for predicting the cooling performance and fuel consumption of engines using these fans, and in comparing one fan versus another.

2. **References**

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

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA15096-0001.

SAE J1342—Method for Determining Power Consumption of Engine Cooling Fan Drive Systems
SAE J1349—Engine Power Test Code—Spark Ignition and Compression Ignition-Net Power Rating

2.1.2   ANSI Publication—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ANSI/AMCA Standard 210-99 ANSI/ASHRAE Standard 51-1999 "American National Standard "Laboratory Methods Of Testing Fans For Aerodynamic Performance Rating"

3.   Test Procedure

3.1   Equipment and Facilities

3.1.1   A calibrated motoring dynamometer

3.1.2   Structure with minimum length, width, and height of 200% of the fan diameter to support a sharp-edge orifice (or other fan shroud), which includes a suitable plenum chamber. A calibrated flow measurement orifice or nozzle should be coupled to this structure. The actual vehicle or other application can be used in place of the fan shroud if a torque meter can be installed, and adequate sealing can be established between the plenum chamber and the vehicle. A separate belt drive using an auxiliary power source can facilitate power measurement. See Figure 1.

3.1.3   A boost fan and/or shutters to vary the plenum pressure.

3.1.4   A calibrated tachometer.

3.1.5   Equipment necessary for measurement of air temperature, barometric pressure, the pressure across the flow measurement orifice, and the pressure inside the plenum chamber.

3.1.6   The ANSI/AMCA Standard 210-99 ANSI/ASHRAE Standard 51-1999 "Laboratory Methods Of Testing Fans For Aerodynamic Performance Rating" is the American National Standard. Although it is primarily for fans with integral housings, its guidelines are applicable for non-ducted fan performance and test apparatus.

3.2   Test Conditions

3.2.1   Standard Test Conditions—The fan is mounted within a sharp-edged orifice which is 104% of the fan diameter but no more than 19.05 mm (0.75 in) larger than the fan diameter. The fan is mounted such that 50% of its projected width penetrates the orifice.

3.2.2   Application Specific Test Conditions—Mount the fan in the shroud intended for the application at the tip clearance and insertion planned for the application and/or with any components used in the application up to and including the complete application or vehicle.

3.2.3   Best Penetration Fan Performance Test Conditions—Mount the fan in a flat plate shroud, or the shroud intended for the application, and adjust the insertion to obtain maximum airflow at each data point.

3.2.4   Specify which test conditions were used on the fan test report, plots, and /or tabulated data.

3.3   Test Procedures—Operate the test fan over a range of speeds representative of the intended use. Select sufficient discrete speeds to establish performance for the speed range. At each discrete test speed vary the plenum pressure across the pressure operating range of the fan in the installation. Usually a minimum of 10 discrete pressure points from zero to maximum pressure would be recorded at each speed. Measure torque, plenum pressure, and the flow nozzle pressure differential at each point. Measure and record laboratory ambient temperature and atmospheric pressure for calculation of air density. Calculate the fan flow, pressure, and power using the formulas of 4.2.
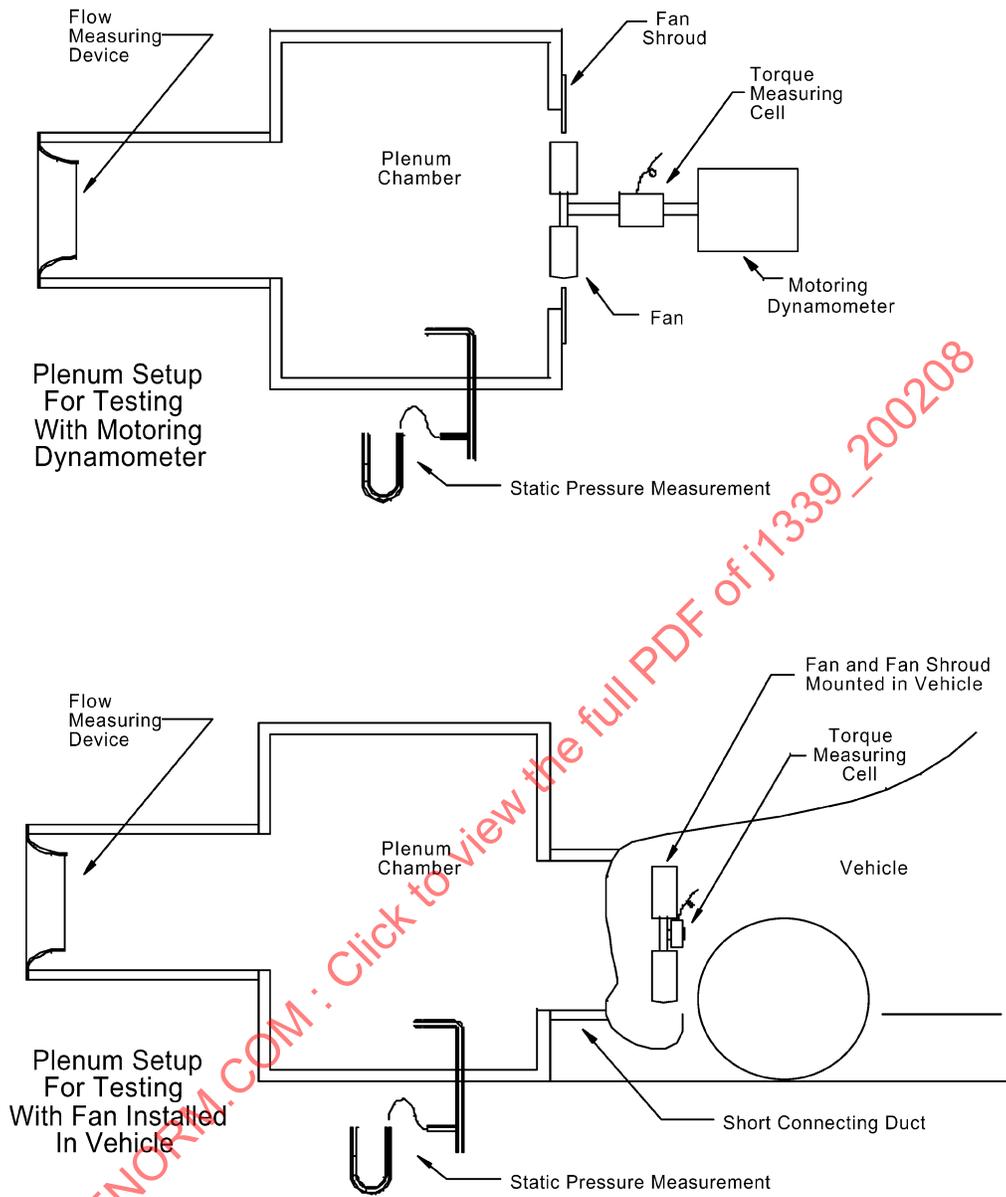
FIGURE 1—FAN PERFORMANCE TEST SET UP

4. *Computations and Results*

4.1 **Definition of Symbols—**See Table 1.

TABLE 1—DEFINITION OF SYMBOLS

Symbol	Definition	Units SI	Units English
A	Absolute temp. conversion factor	273 °C	460 °F
B	Barometric pressure	kPa	in Hg
D	Air density	kg/m^3	lbm/ft^3
t	Ambient temperature	°C	°F
P	Fan power	kW	hp
N	Fan speed	r/min	r/min
T	Fan torque	N-m	lbf-ft
Q	Airflow	m^3/sec	ft^3/min
Ps	Static pressure	kPa	$in-H_2O$
Pd	Nozzle pressure (Delta P)	kPa	$in-H_2O$
Pp	Plenum pressure	kPa	$in-H_2O$
K	Density conversion factor	$\dfrac{3.487 \, kg°C}{m^3 kPa}$	$\dfrac{1.325 \, lbm°F}{ft^3 \, in \, hg}$
X	Power conversion factor	$\dfrac{9549 \, N\text{-}m \, r/min}{kW}$	$\dfrac{5252 \, lbf\text{-}ft \, r/min}{hp}$
Dsa	Standard air density	$1.20 \, kg/m^3$	$0.075 \, lbm/ft^3$
k_f	Flow conversion constant	35.0	5.97
k_n	Nozzle flow coefficient	Function of nozzle geometry	
d_n	Nozzle diameter	meters	inches

Subscripts
c   Corrected to standard air density

4.2 **Calculations**

4.2.1 AIR DENSITY

$$D = KB/(t + A)$$ (Eq. 1)

4.2.2 AIR DENSITY CORRECTION FACTOR

$$C = Dsa/D$$ (Eq. 2)

4.2.3 FAN POWER

$$P = NT/X$$ (Eq. 3)

4.2.4 CORRECTED FAN POWER

$$P_c = PC$$ (Eq. 4)

4.2.5 FAN AIRFLOW (SCFM OR SCMS)

$$Q_c = k_f k_n d_n^2 (P_d/D)^{0.5}$$ (Eq. 5)

4.2.6   FAN STATIC PRESSURE

$$P_{sc} = P_{pc} \qquad \text{(Eq. 6)}$$

4.3   Presentation of Results—The fan flow (Qc), fan static pressure (Psc), and fan power (Pc) shall be plotted at each fan speed N, as shown in Figure 2. When only fan power data are required the fan power shall be plotted versus fan speed at a given system restriction, as shown in Figure 3. The test conditions, i.e., shroud type, fan penetration, air density, fan speed, and any special conditions must be noted on the plots and tabulated data.

Symbol	Part Number	Fan Diameter	Shroud Type	Shroud Diameter	Speed RPM	Fan Penetration
○	ABC123	711 mm	FLAT	730 mm	3000	38 mm
◇	ABC123	711 mm	FLAT	730 mm	2000	38 mm
Δ	ABC123	711 mm	FLAT	730 mm	1000	38 mm
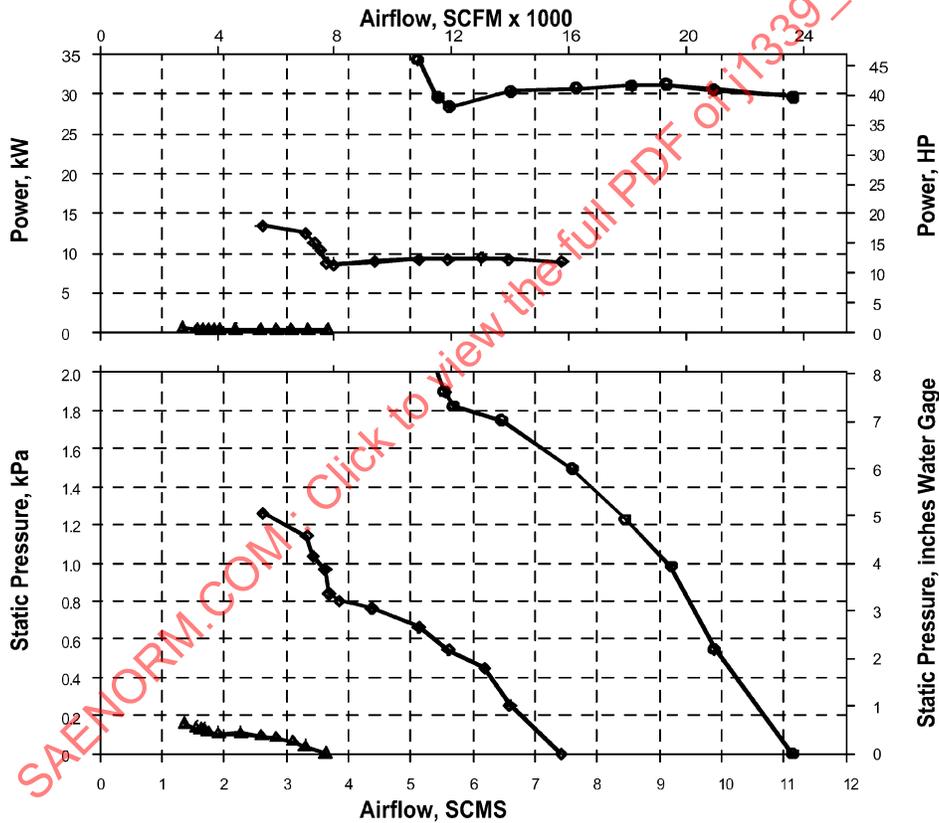
Where: SCMS = standard cubic meters per second

SCFM = standard cubic feet per minute

Presentation of typical fan performance data
711 mm (28 in) diameter, six-blade fan mounted 50% within a sharp-edged orifice with a diameter 19 mm (0.75 in) larger than the fan diameter. Data corrected to standard air density.

FIGURE 2—FAN PERFORMANCE