



SURFACE VEHICLE RECOMMENDED PRACTICE

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Measurement Procedure for Determination of Silencer Effectiveness in
Reducing Engine Intake or Exhaust Sound Level

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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Foreword—This Reaffirmed Document has not changed other than to put it into the new SAE Technical Standards Board Format. References were changed to Section 2. All other section numbers have changed accordingly.

1. Scope—This SAE Recommended Practice sets forth the instrumentation, environment, and test procedures to be used in measuring the silencer system effectiveness in reducing intake or exhaust sound level of internal combustion engines. The system shall include the intake or exhaust silencer, related piping, and components. This procedure is intended for engine-dynamometer testing and is not necessarily applicable to vehicle testing (see Appendix A). The effect of the exhaust or intake system on the sound level of the overall machine must be determined using other procedures. This procedure may be successively applied to various silencer configurations to determine relative effectiveness for that engine. Insertion loss for individual silencers may be calculated through measurement of the silenced and unsilenced system.

2. References

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

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

SAE J184 FEB87—Qualifying a Sound Data Acquisition System

2.1.2 ANSI PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI S1.4-1983 and S1.4A-1985—Specifications for Sound Level Meters

ANSI S1.13-1971 (R1986)—Methods for the Measurement of Sound Pressure Levels

3. Instrumentation—The following instrumentation shall be used for the measurement required:

3.1 A sound level meter which meets the Type 1 or S1A requirements of American National Standard, Specification for Sound Level Meters, S1.4-1983 & S1.4A-1985.

3.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or other indicating instrument, providing the system meets the requirements of SAE J184 FEB87, Qualifying a Sound Data Acquisition System.

- 3.3 A sound level calibrator having an accuracy within ± 0.5 dB. (See 7.2.4.)
- 3.4 A windscreen may be used. The windscreen must not affect the microphone response more than ± 1 dB for frequencies of 20 to 4000 Hz or ± 1.5 dB for frequencies of 4000 to 10 000 Hz. (See 7.3.)
- 3.5 If outside tests are being performed, an anemometer or other means for determination of ambient wind speed having an accuracy within $\pm 10\%$ at 19 km/h (12 mph).
- 3.6 A thermometer or other means for determination of ambient and engine intake air temperature, having an accuracy within ± 1 °C (± 2 °F).
- 3.7 A thermometer or other means for determination of fuel temperature at the fuel pump inlet having an accuracy within ± 1 °C (± 2 °F).
- 3.8 A barometer or other means for determination of ambient and engine intake air barometric pressure, having an accuracy within $\pm 0.5\%$ of the actual value.
- 3.9 A psychrometer or other means for determination of ambient and engine intake air relative humidity, having an accuracy within $\pm 5\%$ of the actual value.
- 3.10 An engine dynamometer with engine speed and torque (or power) indicators having an accuracy within $\pm 2\%$ of the rated engine speed and torque (or power).
- 3.11 A flowmeter or other means for determination of engine fuel rate having an accuracy within $\pm 1\%$ of the rated fuel flow.
4. **Environment**—The silencer shall be measured in an environment such that results are equivalent to those obtained in a free field above a reflecting plane. Measurements may be made at a flat open space or in an acoustically equivalent test site as described in Appendix B.
- 4.1 The flat open space or equivalent test site shall be free from the effect of a large reflecting surface, such as a building or hillside, located within 30 m (100 ft) of either the silencer opening or microphone. The area directly between the silencer opening and the microphone shall be concrete or sealed asphalt with a maximum deviation of ± 0.05 m (± 2 in) from a plane extending at least 3.0 m (10 ft) in all directions from all points on the line segment between the silencer outlet and the microphone.
- 4.2 The ambient A-weighted sound level (including wind effects and other noise sources such as the engine) shall be at least 10 dB lower than the level being measured.
- 4.3 Not more than one person other than the observer reading the meter shall be within 15 m (50 ft) of the silencer opening or microphone, and that person shall be directly behind the observer who is reading the meter, on a line through the microphone and the observer, or behind the silencer under test.
5. **Procedure**
- 5.1 The silencer shall be tested on the engine and silencer system for which data will be reported.
- 5.2 The specified silencer system configuration shall provide for measurement of the acoustical radiation from the surface of the silencer or silencers, connecting pipes, and the acoustical outlet of the system. This does not include piping from the engine to the silencer. The silencer system should be oriented in the same relative position to the ground as for the actual application. Any deviation must be reported with the test data. All system connections are to be free from leaks that will measurably affect test results. For determining the insertion loss, the unsilenced system shall include a pipe of physical length equal to the silencer.

- 5.3** The engine power and fuel rate shall be measured at full load from two-thirds of rated speed to governed speed, or to rated speed on ungoverned engines, to determine whether the engine is within the engine manufacturer's performance specifications prior to proceeding with this test procedure.
- 5.4** The engine shall be operated in the following modes after reaching normal operating conditions:
- Steady-state Mode—Rated engine speed and full load.
 - Varying Speed Full Load Mode—Engine speed to be slowly varied from rated speed to two-thirds of rated speed at wide open throttle.
For governed engines only:
 - Acceleration Mode—Accelerate the engine from idle to governed speed until the engine speed stabilizes and return to idle by rapidly opening and closing the throttle under no load conditions.

6. Measurements

- 6.1** The Microphone shall be located at a height of 1.2 m (4 ft) above the ground plane and at a horizontal distance of 15 m (50 ft) from the centerline of the opening of the silencer system. For a multiple-opening system, the midpoint of the line (or centroid of the plane) connecting the openings shall be used as the reference point for the microphone distance measurement. Other optional distances such as 7.5 m (25 ft) may be used and must be reported. The angular location of the microphone relative to the silencer system opening shall be recorded.
- 6.2** The sound level meter shall be set for fast dynamic response and for the a-weighting network.
- 6.3** For the procedure specified in 5.3 and 5.4, report:
- Engine power and fuel rate as determined in 5.3.
 - Ambient wind speed, ambient temperature, ambient barometric pressure, ambient relative humidity, and ambient a-weighted sound levels for the test site.
 - Maximum a-weighted sound level measured for each test mode in 5.4.
 - Torque (or power), engine speed, engine intake air temperature, barometric pressure, and relative humidity at which the maximum sound level was obtained.
 - Any deviations from recommended test procedure as described in 5.2.
 - The angular location and distance of the microphone relative to the silencer opening.
 - Description of the test configuration, including all critical dimensions.

7. General Comments

- 7.1** It is essential that persons technically trained and experienced in the current techniques of sound measurement select the equipment and conduct the tests.
- 7.2** Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument and manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed. Specific items to be considered are:
- 7.2.1** The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.
- 7.2.2** The effects of ambient weather conditions on the performance of all instruments (for example, temperature, humidity, and barometric pressure). Instrumentation can be influenced by low temperature and caution should be exercised.
- 7.2.3** Proper Signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

- 7.2.4 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before and after field use.
- 7.3 Measurements shall be made only when wind speed is below 19 km/h (12 mph).
- 7.4 It is recommended that a drawing or photograph of the test configuration be included in the reported results.

PREPARED BY THE SAE EXHAUST AND INTAKE SILENCER SUBCOMMITTEE
OF THE SAE VEHICLE SOUND LEVEL COMMITTEE

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