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SURFACE VEHICLE RECOMMENDED PRACTICE

An American National Standard

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Measurement of Light Vehicle Stationary Exhaust System Sound Level Engine Speed Sweep Method

1. *Scope*—This SAE Recommended Practice establishes the test procedure, environment, and instrumentation to be used for measuring the exterior exhaust sound level for passenger cars, multipurpose vehicles, and light trucks under stationary conditions providing a continuous measure of exhaust system sound level over a range of engine speeds.

This sound level measurement procedure has been developed for use in engineering evaluation of the sound level performance of passenger car and light truck exhaust systems. It provides the means for detecting exhaust system resonances with the potential to affect both exterior and interior sound quality.

This document incorporates certain provisions of ISO 5130-1982-02-15, for measuring the sound level of exhaust systems. (See Appendix A.)

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 J184—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—Specification for Sound Level Meters
ANSI S1.40-1984—Specification for Acoustical Calibrators

2.1.3 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 5130-1982-02-15—Acoustics—Measurement of noise emitted by stationary road vehicles—Survey method

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3. Instrumentation

3.1 The instrumentation necessary to conduct this test shall meet minimum performance requirements as specified herein.

3.2 A sound level meter meeting the Type and S1A requirements of ANSI S1.4-1983.

3.2.1 The sound level meter shall be set for the fast exponential time-averaging characteristic, and A-weighting network.

3.2.2 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 indicating instrument, provided the system meets the requirements of SAE J184.

3.3 The calibration of the sound level meter shall be checked and adjusted according to the manufacturer's instructions using a calibrator meeting the requirements of ANSI S1.40-1984 at the start of measurements and rechecked and recorded at the end of them. (See 8.2.)

If the calibration readings of the sound level meter change by more than 0.5 dB during a series of measurements, the test shall be considered invalid.

3.4 A microphone windscreen may be used, provided that it does not affect the microphone response more than ±1 dB for frequencies from 20 to 4000 Hz and ±1.5 dB from 4000 to 10 000 Hz.

3.5 Engine speed shall be measured with an instrument having an accuracy of ±2% or better at the speeds required for the measurements being performed.

4. Test Environment

4.1 A suitable test site shall be out-of-doors and consist of a level concrete, asphalt, or similar hard material flat surface, free from snow, grass, loose soil, ashes, or other sound absorbing material. It shall be in an open space free from large reflecting surfaces, such as parked vehicles, buildings, billboards, trees, shrubbery, parallel walls, people, etc., within a 3 m radius from the microphone location and any point on the vehicle.

4.1.1 As an alternative to outside testing, a large hemi-anechoic chamber may be used.

4.2 The ambient sound level (including wind effects) from sources other than the vehicle being tested shall be at least 10 dB below that produced by the test vehicle.

5. Microphone Orientation

5.1 The microphone shall be located at a distance of 0.5 m from the reference point on the exhaust outlet pipe (refer to Figure 1) and at an angle of 45 degrees (+0, –10 degrees) to the flow axis of the pipe termination (refer to Figure 2). The microphone shall be at the height of the reference point, but not less than 0.2 m from the ground surface. The reference axis of the microphone shall lie in a plane parallel to the ground surface and shall be directed toward the reference point on the exhaust outlet. (See 5.2 and 5.3) .

5.1.1 If two microphone locations are possible, the location furthest laterally from the vehicle longitudinal centerline shall be used.

5.1.2 If the flow axis of the exhaust outlet pipe is at 90 degrees to the vehicle longitudinal centerline, the microphone shall be located at the point, determined in accordance with 5.1, which is furthest from the engine.

5.2 For exhaust outlets located under the vehicle body, the microphone shall be located a minimum of 0.2 m from the nearest part of the vehicle, at a point closest to, but not less than 0.5 m from, the exhaust outlet, and at a height of 0.2 m above the ground surface, and not in line with exhaust flow. The angularity requirement of 5.1 may not be met in some cases. (Refer to Figure 2.)

5.3 If a vehicle has two or more exhaust outlets spaced less than 0.3 m apart and connected to a single silencer, only one measurement shall be made. The microphone shall be located relative to the outlet furthest from the vehicle longitudinal centerline, or when such outlet does not exist, to the outlet which is highest above the ground.

6. Procedure

6.1 The engine of the vehicle under test shall be at normal operating temperature during the test.

6.2 The engine hood or compartment cover shall be closed.

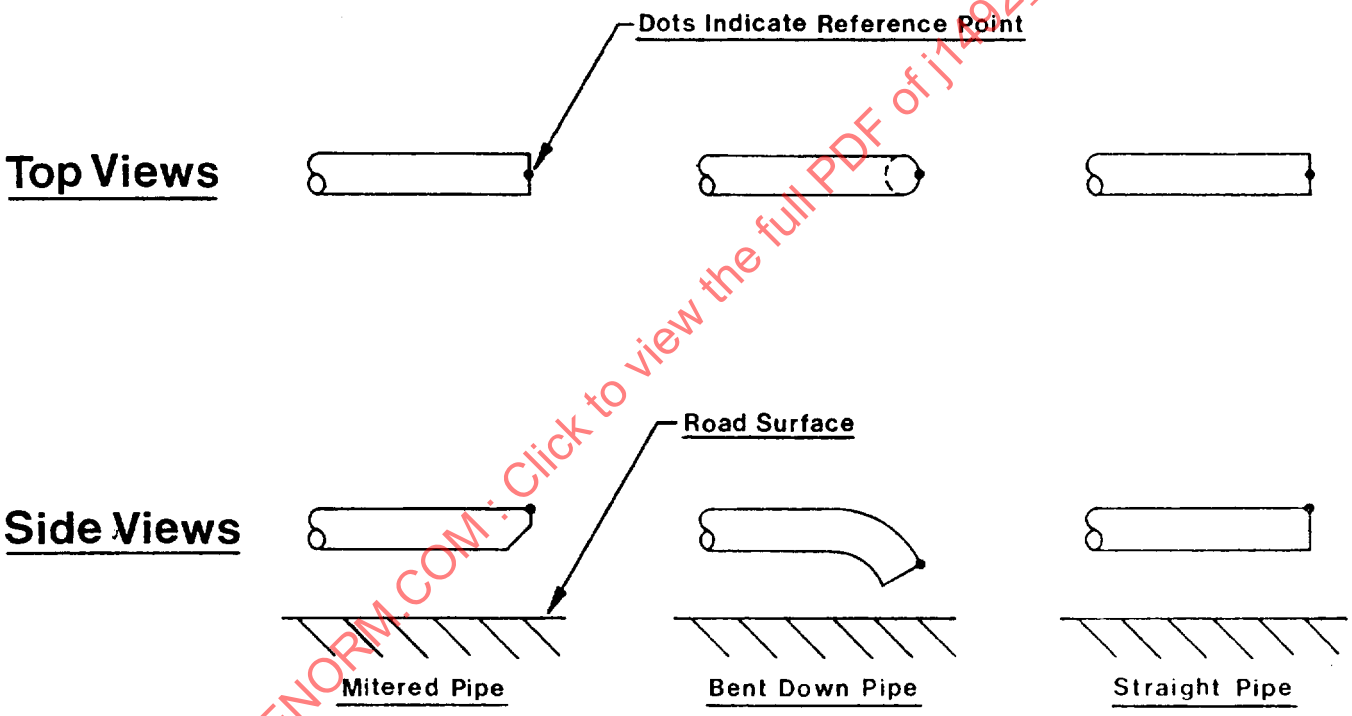

FIGURE 1—OUTLET PIPE DETAILS

6.3 The vehicle air conditioner, if so equipped, shall be turned off.

6.4 The vehicle transmission shall be in the neutral or park position and the parking brake applied for safety.

6.5 Test Operation

6.5.1 The sound level meter shall be set for the fast exponential time-averaging characteristic.

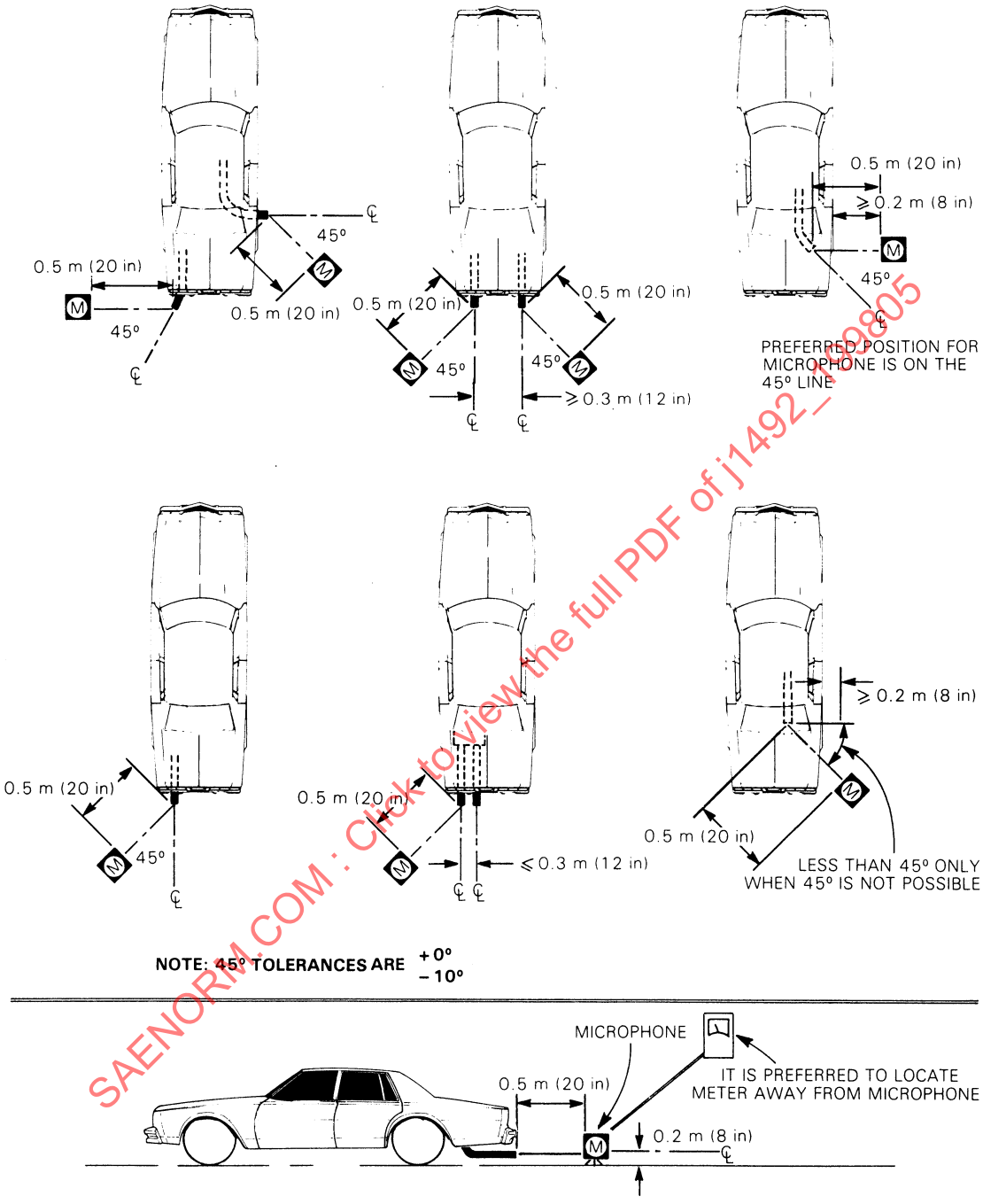

FIGURE 2—MICROPHONE LOCATION SKETCH

6.5.2 The engine speed shall be gradually increased from idle to 3/4 of the engine speed at rated horsepower and held constant at that speed for 1 to 2 s. Then the throttle shall be rapidly released and the engine allowed to return to idle. Measure the sound level during this entire cycle.

NOTE—The change from idle up to 3/4 rated engine speed should occur over a 10 to 15 s interval. Some engines exhibit sensitivity to the rate of increase. The longer time interval tends to reduce run-to-run variability.

6.5.3 Vehicles equipped with a multi-mode exhaust system and a manual exhaust mode control switch shall be tested according to 6.5.2 with the mode switch in all positions.

7. Measurements

7.1 Measurements shall be made at each exhaust outlet, using the microphone location(s) described in Section 5.

7.2 The sound level meter shall be observed during the entire cycle as described in 6.5.2. The recorded reading shall be the highest sound level observed.

7.2.1 The test shall be repeated at each exhaust outlet until two measurements are obtained which are within 2 dB of each other.

7.2.2 The reported sound level for a given outlet shall be the arithmetic average of the two highest measurements which are within 2 dB of each other.

7.2.3 A spot check is recommended when the sound level during the speed sweep is within 3 dB of the maximum allowable value. The exhaust system sound level at a specific constant engine speed may be performed with the engine speed held constant at the r/min of interest (e.g., 2500 r/min, 3000 r/min or 3/4 of rated engine speed) following the procedures outlined in SAE J1169 or ISO 5130.

7.3 When the test instrumentation used is capable of sampling the sound level at selected engine speeds (r/min) during the speed sweep, both the maximum level for the engine speed sweep and the level at each preselected r/min shall be recorded.

7.4 For vehicles equipped with multiple exhaust gas outlets, the sound level reported shall be for the outlet having the highest average sound level.

7.4.1 For vehicles equipped with a multi-mode exhaust system, the sound level reported shall be for the outlet and the mode yielding the highest average sound level.

8. General Comments

8.1 It is essential that persons technically trained and experienced in current sound measurement techniques select the test instrumentation and conduct the tests.

8.2 An external acoustic calibration shall be performed immediately before and after each period of field use following the instrument manufacturer's recommended calibration practice.

8.3 It should be recognized that variations in measured sound levels may occur due to variations in test sites, atmospheric conditions and test equipment.

8.4 Caution should be exercised when measuring rear- and mid-engine vehicles because engine and cooling fan noise may prevent accurate measurement of exhaust noise.

8.5 Instrument manufacturer's specifications for orientation of the microphone relative to the sound source and the location of the observer relative to the microphone shall be followed. The test may be performed with a hand-held sound level meter. However, it is recommended that the sound level meter or microphone be mounted on a stand or fixture for stability. When possible, it is preferable to use a microphone extension cable and to locate measurement or recording devices away from the microphone.

9. Notes

9.1 **Marginal Indicia—**The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE VEHICLE SOUND LEVEL STANDARDS FORUM COMMITTEE AND
THE SAE LIGHT VEHICLE EXTERIOR SOUND LEVEL

APPENDIX A

A.1 ***General—***This appendix contains a discussion of the rationale for the development of a stationary exhaust system sound level test procedure using a continuous sweep over a range of engine speeds.

This test procedure provides the means for identification of exhaust system resonances with implications for both interior and exterior sound quality. It also provides a quick and simple test method for screening exhaust systems with respect to sound level performance according to regulatory requirements for light vehicle exhaust equipment.

A.1.1 Rationale—SAE J1492 differs from SAE J1169 in that it provides a more comprehensive approach to stationary exhaust system sound level testing utilizing an engine speed (r/min) sweep test. The speed sweep permits continuous evaluation of exhaust system sound level performance over a range of engine speeds. SAE J1169 contains a single 3/4 of rated engine speed, steady-state, test criterion for stationary exhaust system sound level testing. SAE J1492 also includes provisions for exhaust system sound level testing in accordance with ISO 5130 which includes an engine deceleration.

The stationary exhaust system noise test was initially developed to fill the need for a quick and easy in-use light vehicle noise enforcement test procedure. The test, as applied in the State of California, used the single criterion of 3/4 of rated engine speed. The stationary test was also adopted for use in qualifying replacement exhaust equipment in the States of California and Florida. SAE responded by developing SAE J1169 using a single 3000 r/min criterion which has been revised to 3/4 of rated engine speed. The State of Oregon later adopted the stationary noise test at 2500 rpm in biennial exhaust emissions test regulations.

Since its inception, the stationary test has been determined to be a valid, objective test for evaluation of exhaust system noise performance.

In efforts to develop a single test for compliance with all stationary exhaust system noise requirements, engineers developed the engine speed sweep test. It provides objective criteria for evaluation of exhaust system noise performance and allows identification of system resonances that may affect both interior and exterior sound quality.

The engine speed sweep technique presents technical and practical advantages that can reduce test time and provide a comprehensive evaluation of exhaust system noise performance across a range of engine operating conditions.

Incorporation of a 3 dB guideline is based on a comparison of empirical data for vehicles tested to the speed sweep and constant speed methods. These results indicate differences of less than 3 dB between the two test methods. For this reason, it is recommended that the constant speed test, using test procedures set forth in either SAE J1169 or ISO 5130, also be performed at critical r/min for vehicles with exhaust system engine speed sweep sound level test results within 3 dB of prescribed limit values.

Type 2 and 2A, Sound Level Meters, are to be deleted as they are no longer considered to be the precision devices received, for this type of test.

Changes made in Sections 3.3 and 3.5 are to improve the precision of the measurements.