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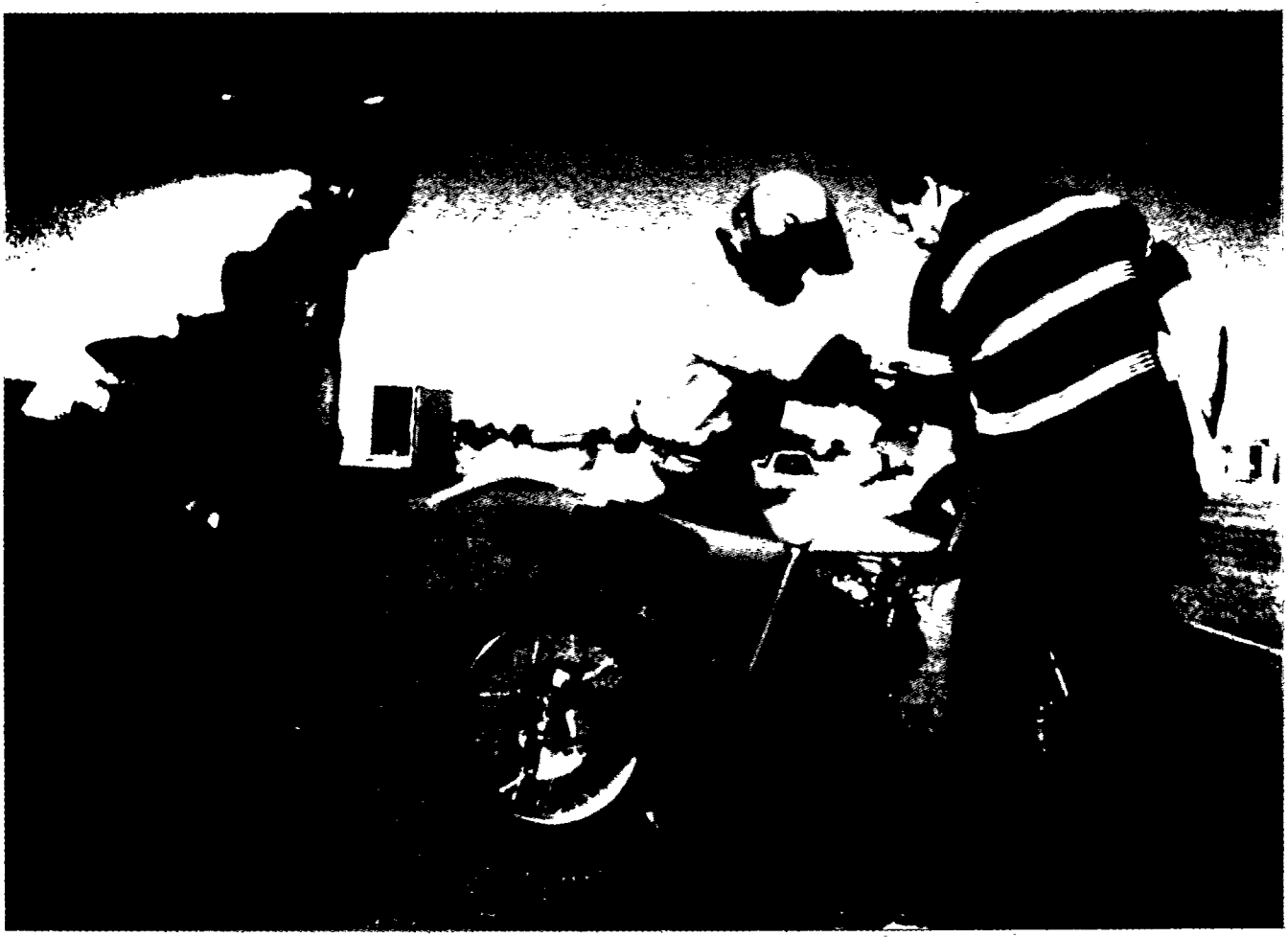
Correlation of Off-Highway Motorcycle Sound Test Methods:

EPA/SAE

**MOTORCYCLE
INDUSTRY
COUNCIL, INC.**



Correlation of Off-Highway Motorcycle Sound Test Methods: EPA/SAE

Robin T. Harrison, P.E.
Aviation Program Leader

and

William J. Makel
Recreation Program Leader

Technology & Development Program
San Dimas, California 91773-3198

J. C. DeLaney
Technical Programs Manager

Motorcycle Industry Council, Inc.
2 Jenner Street. Suite 150
Irvine, California 92718-3812

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Noise Control in Forest Recreation

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PREFACE

This Project Report results from a joint project conducted by the USDA Forest Service Technology and Development Center, San Dimas, CA, and the Technical Committee of the Motorcycle Industry Council, Inc. (MIC), Irvine, CA. A Memorandum of Understanding was entered into by the two parties on April 12, 1991, "to cooperate in a correlation study of off-highway motorcycle sound levels and emission measurement methods" and that "a joint technical report will be written by members of the MIC Technical Committee and the Forest Service."

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BACKGROUND

The San Dimas Technology and Development Center (SDTDC) and the Motorcycle Industry Council (MIC), a nonprofit organization, entered into a Memorandum of Understanding (MOU) in April 1991. This MOU covered an investigation into whether a correlation exists between sound levels obtained by:

- U.S. Environmental Protection Agency (EPA) Motorcycle Noise Emission Test Procedures, F-76a (appendix A)
- Society of Automotive Engineers (SAE) Standard, Measurement of Exhaust Sound Levels of Stationary Motorcycles, J1287 (appendix B).

The investigative test was conducted on current production off-highway motorcycles under the terms and conditions of the MOU; publishing of this joint report constitutes fulfillment of the MOU.

INTRODUCTION

EPA Test Procedure F-76a

The EPA classifies off-highway motorcycles into small and large categories and has set standards for motorcycle noise emissions. The requirements are stated in terms of EPA Test Procedure F-76a (Environmental Protection Agency, 1980), a complicated engineering test which evaluates the sound emitted by the total motorcycle while accelerating. The limits prescribed in 40 CFR 205.152 for 1986 and later model year motorcycles are 80 dB(A) for all street (including dual-purpose) motorcycles, 80 dB(A) for all off-highway motorcycles of 170 cc or less, and 82 dB(A) for all motorcycles greater than 170 cc. All new dual-purpose and off-highway motorcycles sold in the United States must conform to these standards.

The EPA Motorcycle Noise Test Procedure was designed to measure the total sound emission from accelerating motorcycles. It requires a large flat open space free of large sound-reflecting surfaces within 30 meters of the microphone and the test motorcycle. It measures the level of total motorcycle sound emissions as the motorcycle accelerates past a target point at a distance of 15 meters from the microphone. It is impractical for field enforcement efforts under the conditions found at most public riding areas.

SAE Standard J1287

To allow for relatively easy in-use testing, the SAE developed a stationary sound test, SAE J1287, last revised in 1988. This test method has been widely adopted by authorities responsible for managing off-highway vehicle recreation.

A number of National Forests are also currently using this method to regulate motorcycle noise under the authority of 36 CFR 261.13(d). Its use is promoted by the MIC. SAE J1287 measures exhaust noise 20 inches from the muffler outlet while the motorcycle is stationary and the engine is operated at a specified steady engine speed. The method was intended to be quick, easily run, easily understood, and to be able to identify excessively loud motorcycles.

Correlation of Methods

Implicit in this scheme is the assumption that a correlation exists between sound levels measured by the EPA F-76a method and sound levels measured by the SAE J1287 method. A study sponsored by the MIC and conducted by McDonnell-Douglas Astronautics Co. West (Hornett, et. al., 1975) did establish that a relationship does exist between a method similar to SAE J1287 and a method similar to EPA F-76a. A 1981 study sponsored by the EPA and conducted by the National Association of Noise Control Officials (Borthwick, et. al., 1982) supported the use of SAE J1287 as an in-use enforcement procedure to identify motorcycles having EPA F-76a levels greater than 86 dB(A). However, no formal test of this relationship between J1287 and F-76a, for newer motorcycles and all-terrain vehicles has been published.

Investigative Limits

It has been determined that 99 dB(A) measured by J1287 roughly discriminates between motorcycles which meet 86 dB(A) measured by the F-76a method and motorcycles which have higher noise levels. Federal law changed in 1986, and now allows a maximum sound level of only 82 dB(A) for motorcycles greater than 170 cc and just 80 dB(A) for motorcycles of 170 cc or less. No known testing for correlation between the EPA F-76a and the SAE J1287 test methods has been done for 1986 and later model year motorcycles.

TEST MOTORCYCLES AND INSTRUMENTATION

Each participating MIC member delivered the motorcycles to be tested to the test site along with all support personnel necessary to ensure the timely completion of tests. MIC provided the trained test rider, who did all of the test riding.

At least one motorcycle was tested from each of the following categories:

- Type 1: Small ($\leq$170 cc), two-stroke engine
- Type 2: Small ($\leq$170 cc), four-stroke engine
- Type 3: Large (>170 cc), two-stroke engine
- Type 4: Large (>170 cc), four-stroke engine.

Appendix C contains the individual test motorcycle specifications. Because the purpose of this study was solely to determine whether a correlation exists between the EPA and SAE test methods, the motorcycles are not identified by brand name or model number.

Several aftermarket exhaust system manufacturers were invited to participate, but only one did.

Sound level meters, a portable computer, software for engine speed calculation, and other ancillary equipment, which meet the requirements of the applicable test procedures, were used during each test run. The sound level measuring system was calibrated prior to the test to ensure the system met the performance standards of ANSI S1.4-1983, type I. An acoustic calibrator with an accuracy of +0.5 dB(A) was used. It had been calibrated by the manufacturer within the past year. All sound level instrumentation was provided by the SDTDC.

An indirect engine speed measurement system, utilizing a computer and specialized software, was used in the EPA test procedure. An external vibrating reed tachometer was used for the SAE tests. Appendix D contains instrument data.

TEST MEASUREMENT PROCEDURES

The study was conducted on January 14, 1992, in the paved parking lot at the Los Alamitos Race Track, Los Alamitos, CA. This site meets the requirements of the EPA and SAE test methods. After making sufficient practice runs to establish the acceleration point, the EPA test was run for the first test motorcycle. Immediately after completion of the EPA test method, the SAE test method was utilized. This sequence was followed until all motorcycles were tested. Appendix E contains test site data and the measured sound levels for all runs.

DATA ANALYSIS AND TEST RESULTS

Eight motorcycles were available for testing. While a small sample, the data spread and the variety of the defined motorcycle categories represents a broad enough range to indicate that there is no linear correlation between the EPA F-76a noise test and the SAE J1287 stationary sound test. Figure 1 compares the EPA and SAE test results for the eight motorcycles tested.

Figures 2 and 3 compare the test results for two-stroke and four-stroke motorcycles. Because of the small sample, the data are insufficient to establish a firm conclusion. However, the results indicate that for current production motorcycles meeting EPA standards, the average difference between the EPA test results and SAE test results may be greater for two-stroke motorcycles than four-stroke motorcycles. The highest SAE J1287 result for two-stroke motorcycles was 93 dB(A) while the highest for four-stroke motorcycles was 88 dB(A).

The EPA F-76a test results for the eight motorcycles tested varied from 79.1 to 91.5 dB(A). The only motorcycle exceeding EPA standards was test vehicle number 8 which used an after-market muffler. The SAE J1287 test results varied from 83.8 to 93.0.

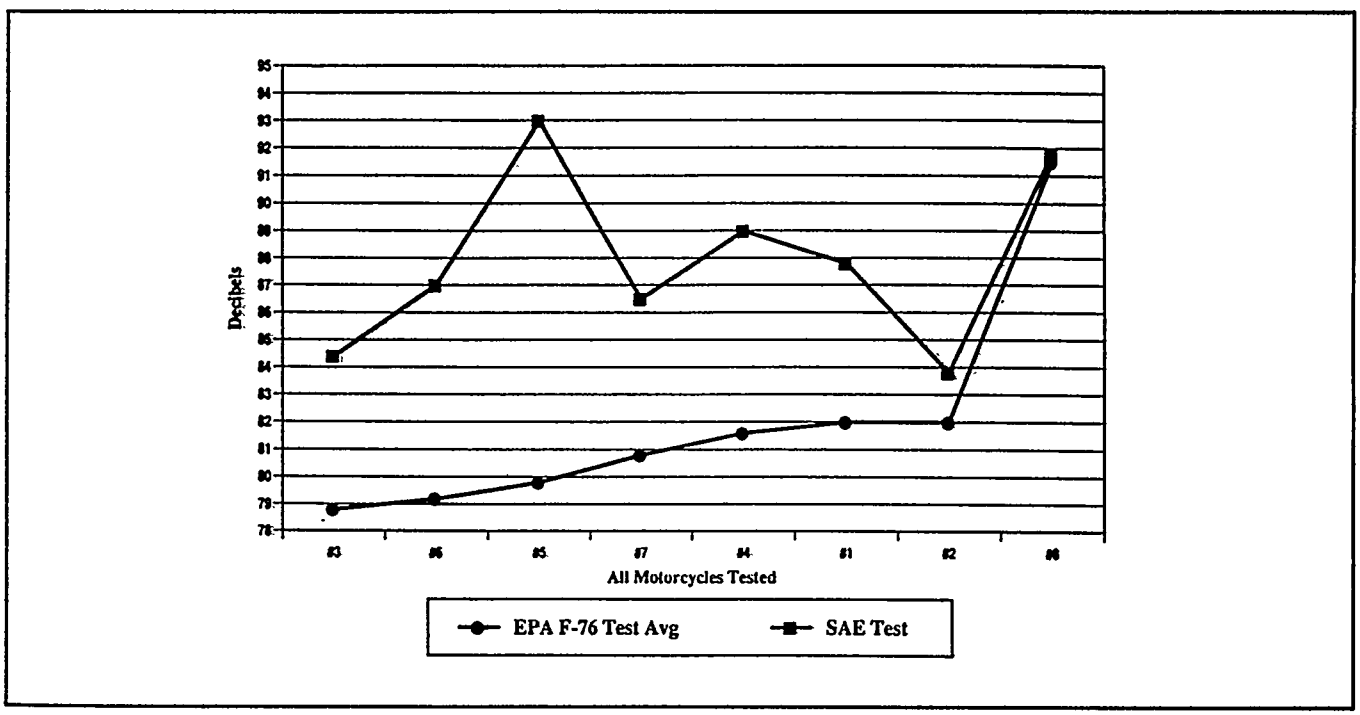


Figure 1.—EPA and SAE test results for all motorcycles tested.

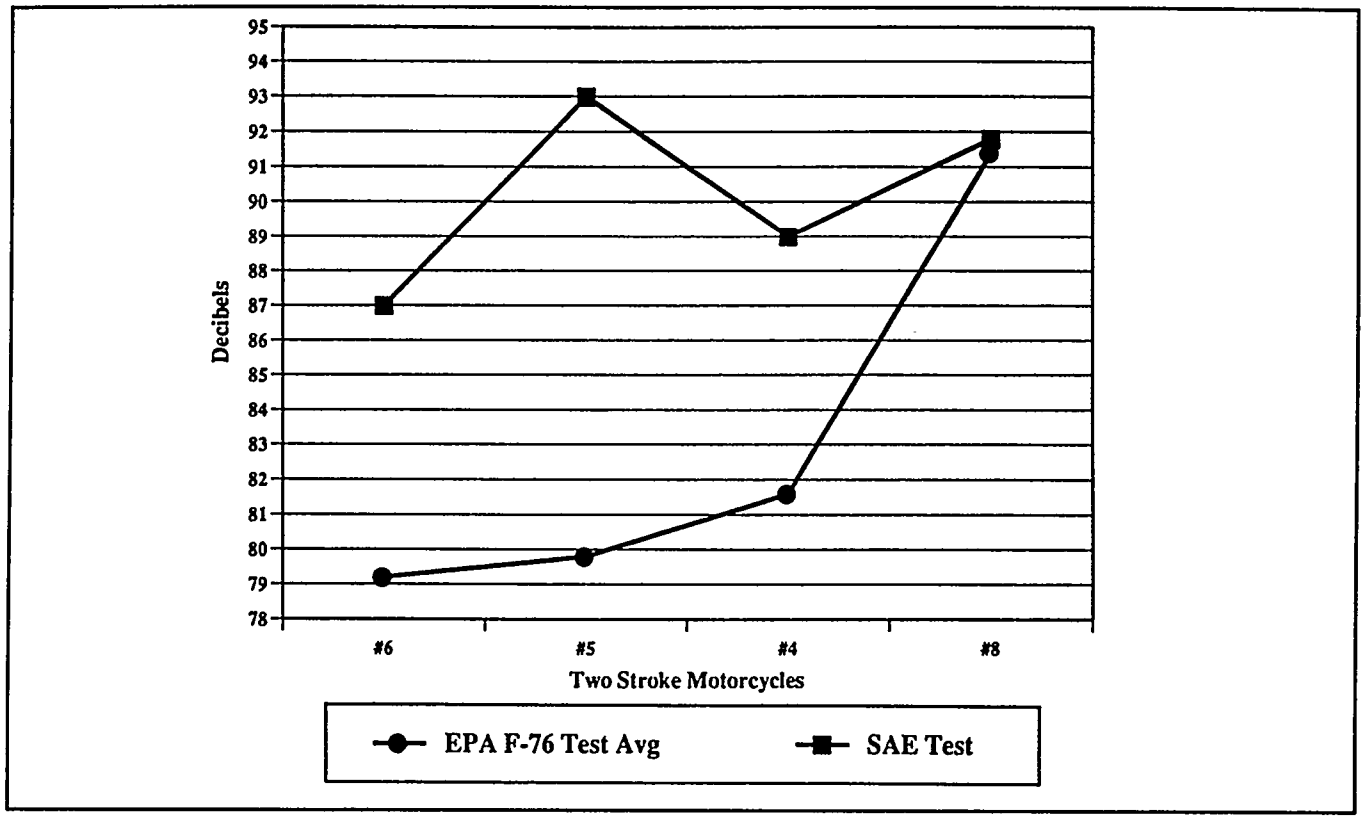


Figure 2.—EPA and SAE test results for two-stroke motorcycles tested.

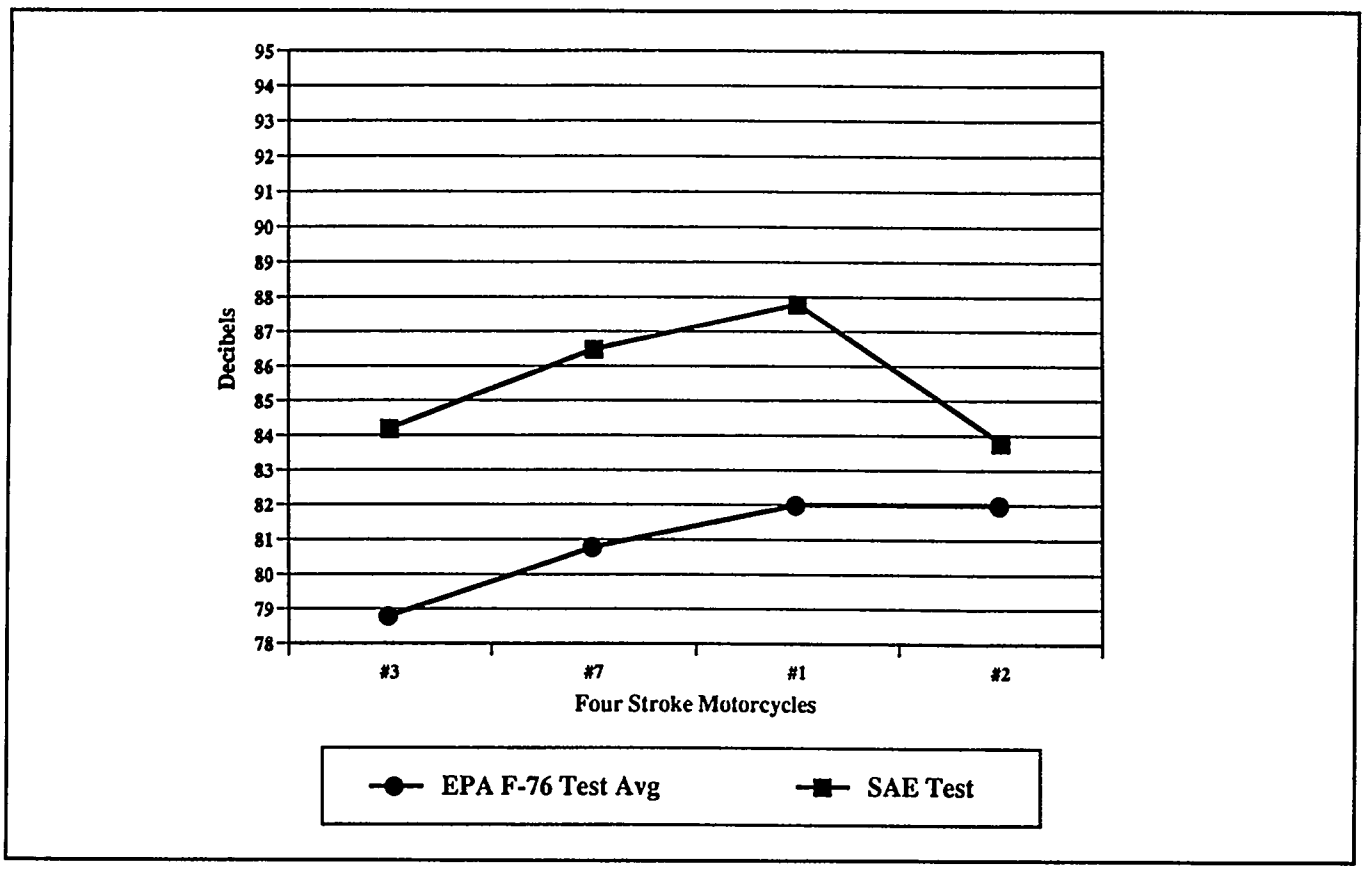


Figure 3.—EPA and SAE tests results for four-stroke motorcycles tested.

CONCLUSIONS

When SAE J1287 was developed in the 1970's, the dominant noise source on off-highway motorcycles was the exhaust note. The test results shown in appendix E indicate that this may no longer be true. In many instances, drive train, tire/surface interaction, engine intake, and other sources may be dominant. Many newer model off-highway motorcycles employ design features not commonly used in the 1970's—such as high-absorption silencers, liquid cooling, power valves, etc.

There is no apparent linear correlation between the results of the two test methods. Thus, SAE J1287 cannot be used to determine the EPA F-76a sound level of a motorcycle and no such attempts should be made. However, this is not to say that no relationship exists between SAE J1287 and EPA F-76a. A comparison of SAE J1287 test results for motorcycles that meet the current EPA standards with the test results of older studies indicate that the reduction in EPA noise standards has also led to a reduction in the sound levels measured using the stationary test procedure.

SAE J1287 remains the best available method for noise measurement under typical field enforcement conditions. With appropriately set maximum sound levels based on a motorcycle's year of manufacture, it can be used to screen out excessively noisy motorcycles while not discriminating against motorcycles which meet EPA standards. The results of this testing indicate that current model motorcycles meeting the January 1986 EPA standards are quieter than earlier models when measured under the SAE J1287 standard.

No "in-use" motorcycles were tested, so the impact of normal deterioration could not be established. It seems likely that motorcycles will become somewhat louder over several seasons due to normal usage wear and tear. Any limits for in-use motorcycles should consider this. The purpose of the effort described in this report was solely to determine whether a correlation exists between the EPA and SAE test methods. Therefore, no recommendations for any particular in-use sound level limit are made.

Any further reductions in sound levels measured by the EPA F-76a method are less likely to lead to corresponding reductions in the sound levels measured by the SAE J1287 method, since exhaust is no longer the dominant noise source on many of the new model motorcycles.

REFERENCES

Borthwick, Jesse O.; Roberts, Jerry E., Jr.; Hagerty, Kevin; and Vitale, Anthony, "Evaluation of Alternate Motorcycle Noise Stationary Test Procedures," 1982 National Conference on Environmental and Occupational Noise.

Hornett, H. and Miyamoto, M., "Evaluation of Community Noise Impact and Noise Test Methods," McDonnell Douglas Astronautics Company for the Motorcycle Industry Council, Inc.

Society of Automotive Engineers, Inc., "Measurement of Exhaust Sound Levels of Stationary Motorcycles," SAE Standard J1287 Jun88.

U.S. Environmental Protection Agency, "Motorcycle Noise Emission Test Procedures," 40 CFR Ch.1, Pt. 205, subpts. D and E, App. 1.

APPENDIXES

APPENDIX A
EPA Test Procedure F-76a

This appendix contains a copy of the EPA test procedure used in the test.

APPENDIX I TO SUBPARTS D AND E—MOTORCYCLE NOISE EMISSION TEST PROCEDURES

APPENDIX I-1 TO SUBPARTS D AND E—TEST PROCEDURE FOR STREET AND OFF-ROAD MOTORCYCLES

(a) *Instrumentation.* Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer must be referred to for both recommended operation of the instrument and precautions to be observed. The following instrumentation must be used, where applicable:

(1) A sound level measurement system which meets the type S1A requirements of American National Standard Specification for Sound Level Meters, ANSI S1.4–1971. 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 that the system meets the performance requirements of ANSI S1.4-1971. The sound level measurement system must be calibrated at least annually to insure that the system meets the performance requirements of ANSI S1.4-1971.

(2) An acoustic calibrator with an accuracy of within ±0.5 dB. The calibrator must be checked annually to verify that its output is within the specified accuracy.

(3)(i) An engine speed measurement system having the following characteristics:

(A) Steady-state accuracy of within ±3% of actual engine speed in the range of 45% to 100% of the engine speed (RPM) where peak net brake power (maximum rated RPM) is developed; and

(B) Response characteristics such that, when closing RPM is indicated under an acceleration as described below, actual engine speed is no more than 3 percent (of closing RPM) greater than the specified closing RPM.

(ii) The vehicle tachometer may be used to ascertain:

(A) The approach RPM provided its meets the specifications in paragraph (a)(3)(i)(A).

(B) The closing RPM provided it meets the specifications in paragraphs (a)(3)(i)(A) and (B).

(iii) Indirect engine speed measurement systems, such as systems which determine engine speed from vehicle speed measurement, may be used provided the specifications of paragraph (a)(1)(i) are met.

(4) An anemometer with steady-state accuracy of within ±10% at 20 km/h (12.4 mph).

(5) A microphone wind screen which does not affect microphone response more than ±0.5 dB for frequencies of 20–4000 Hz or ±1.0 dB for frequencies of 4000–10,000 Hz, taking into account the orientation of the microphone.

(b) *Test site.* (1) The measurement area within the test site must meet the following requirements and be laid out as described:

(i) The following points must be established:

(A) Microphone target point—a reference point on the vehicle path;

(B) End point— a point on the vehicle path 7.5 ± 0.3m (24.6 ± 1.0 ft) beyond the microphone target point, and

(C) Microphone location point—a point 15± 0.3m (49.2 ± 1.0 ft) from the microphone target point on a normal to the vehicle path through the microphone target point.

(ii) The microphone must be:

(A) Positioned at the microphone location point 1.2 ± 0.1 m (3.9 ± 0.3 ft) above the ground plane; and

(B) Oriented in a plane perpendicular to the vehicle path, and at an angle for which the microphone was calibrated to have the flatest response characteristics over the frequency range of 100 Hz to 10,000 Hz when measured with respect to the motorcycle source.

(iii) The surface of the ground within at least the triangular area formed by the microphone location and the points 15 ± 0.3m (49.2 ±1.0 ft.) prior to and 15 ± 0.3 m (49.2 ± 1.0 ft.) beyond the microphone target point must be flat (+ 5 cm (2.0 in)) and level (grade not more than 0.5% along vehicle path), have a concrete or sealed asphalt surface, and be free from snow, soil or other extraneous material.

(iv) The vehicle path must be relatively smooth and of sufficient length for safe acceleration, deceleration and stopping of the motorcycle.

(2) The test site must be flat, open space free of large sound-reflecting surfaces (other than the ground), such as parked vehicles, sign-boards, buildings or hillsides located within a 30 ± 0.3 m (98.4 ± 1.0 ft) radius of the microphone location and the following points on the vehicle path (see Figure 1):

(i) The microphone location point;

(ii) A point 15 ± 0.3 m (49.2 ± 1.0 ft.) before the microphone target point; and

(iii) A point 15 ± 0.3 m (49.2 ± 1.0 ft) beyond the microphone target point.

(c) *Measurement procedure.*

(1) To establish the acceleration point, the end point must be approached in second gear from the reverse of the intended test direction at a constant engine speed of 50% of maximum rated RPM or closing RPM less ten percent of (of maximum rated

RPM), whichever is lower. (±2.5% of observed reading). When the front of the motorcycle reaches the end point (approached from the reverse direction), the throttle must be smoothly and fully opened to accelerate the motorcycle past the microphone target point under wide open throttle. When the motorcycle reaches closing RPM the throttle must be smoothly and fully closed. An ignition disable device may be used to turn off the engine at closing RPM in lieu of closing the throttle manually. The location of the front of the motorcycle at the time of throttle closure is the acceleration point for the test runs. The test runs must be made in the opposite direction. A sufficient number of trial runs must be made to assure accurate establishment of the acceleration point.

(2) Closing RPM must be determined according to the motorcycle engine displacement, as follows (see Figure 2):

Displacement (cc)	Closing RPM (Fraction of maximum rated RPM—percent)
0 to 175	95
176 to 675	109 to 0.08 × (engine displacement in cc)
676 and above	55

(3) The distance from the acceleration point to the end point must be at least 10 m (32.8 ft). If this distance is less than 10 m (32.8 ft) by the procedure specified in paragraph (c)(1), above, third gear, if the motorcycle is so equipped, must be used. If the distance is still less than 10 m (32.8 ft), fourth gear, if the motorcycle is so equipped, must be used, and so on. If closing RPM is reached before the vehicle travels 10 m (32.8 ft), with the vehicle in its highest gear, the throttle must be opened less rapidly, but in such a manner that full throttle and closing RPM are attained at the end point.

(4) If the motorcycle is equipped with an automatic transmission, the procedure specified in paragraph (c)(1), must be followed except that the lowest selectable range must be employed, and the procedure specified in paragraph (c)(3) must be followed using the next selectable higher range, if necessary, and if the vehicle is so equipped. If closing RPM is reached before the vehicle travels 10 m (32.8 ft.), the throttle must be opened less rapidly, but in such a manner that full throttle and closing RPM are attained at the end point.

(5) Throttle opening must be controlled to avoid excessive wheel slip or lift-off.

(6) To conduct a sound measurement, the motorcycle must proceed along the vehicle path in the forward direction in second gear (or higher gear as applicable under paragraph (c)(3)) at a constant engine speed of 50% of maximum rated RPM or at closing RPM less ten percent (of maximum rated RPM), whichever is lower (± 2.5 percent of observed reading). When the front of the vehicle reaches the acceleration point, the throttle must be smoothly and fully opened. Full acceleration must continue until closing RPM is reached, which must occur within ± 1.0 m (3.3 ft.) of the end point, and at which time the throttle must be smoothly and fully closed. An ignition disable device may be used to turn off the engine at closing RPM in lieu of closing the throttle manually.

(7) A sufficient number of preliminary runs must be conducted before the testing to familiarize the rider with the test procedure and operating conditions of the vehicle. The engine temperature must be within the normal operating range prior to each run.

(d) *Measurements.* (1) The sound level meter must be set for fast response and for the A-weighting network. The microphone wind screen must be used. The sound level meter must be calibrated with the acoustic calibrator as often as is necessary throughout testing to maintain the accuracy of the measurement system.

(2) The sound level meter must be observed throughout the acceleration period. The highest sound level obtained for the run must be recorded.

(3) Measurements must be made until at least four readings from each side are within 2 dB of each other. The noise level for each side is the average of the four which are within 2 dB of each other. The noise level reported must be for that side of the motorcycle having the highest noise level.

(4) While making sound level measurements, not more than one person other than the rider and the observer reading the meter may be within 15 m (49.2 ft) of the vehicle or microphone, and that person must be directly behind the observer reading the meter, on a line through the microphone and the observer.

(5) The ambient noise level (including wind effects) at the test site due to sources other than the motorcycle being measured must be at least 10 dB lower than the noise level at the microphone location produced by the motorcycle under test.

(6) Wind speed at the test site during tests must be less than 20 km/h (12.4 mph).

(e) *Required data.* For each valid test, the following data must be recorded:

(1) Motorcycle type, serial number, model year, and date of manufacture.

(2) Names of persons conducting test.

(3) Test location.

(4) Wind speed and ambient noise level measured on the same day as the test and representative of conditions during the test.

(5) Motorcycle engine displacment, maximum rated RPM, and closing RPM.

(6) The gear used for testing if other than second gear; or type of transmission and description of testing if motorcycle is equipped with automatic transmission.

(7) Description of the sound level meter including type, serial number, and calibration date.

(8) Description of the external acoustic calibrator including type, serial number, and calibration date.

(9) Description of the tachometer or engine speed measurement system used for conducting the test.

(10) Maximum noise level for each pass on each side of the motorcycle including invalid readings and reasons for invalidation.

(11) Reported noise level.

(12) Other information as appropriate to completely describe testing conditions and procedure.

APPENDIX I-2 TO SUBPARTS D AND E—TEST PROCEDURE FOR STREET MOTORCYCLES THAT MEET THE DEFINITION OF § 205.151(A)(2)(II) (MOPED-TYPE STREET MOTORCYCLES)

(a) *Instrumentation.* Proper usage of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer must be referred to for both recommended operation of the instrument and precautions to be observed. The following instrumentation must be used, where applicable:

(1) A sound level measurement system which meets the type SIA requirements of American National Standard Specification for Sound Level Meters, ANSI S1.4-1971. 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 that the system meets the performance requirements of ANSI S1.4-1971. The sound level measurement system must be calibrated at least annually to insure that the system meets the performance requirements of ANSI S1.4-1971.

(2) An acoustic calibrator with an accuracy of within ±0.5 dB. The calibrator must be checked annually to verify that its output is within the specified accuracy.

(3) An anemometer with steady-state accuracy of within ±10% at 20 km/h (12.4 mph).

(4) A microphone wind screen which does not affect microphone response more than ±0.5 dB for frequencies of 20-4000 Hz or ±1.0 dB for frequencies of 4000-10,000 Hz, taking into account the orientation of the microphone.

(b) *Test site.* (1) The measurement area within the test site must meet the following requirements and be laid out as described:

(i) The following points must be established:

(A) Microphone target point—a reference point on the vehicle path;

(B) End point—a point on the vehicle path 7.5±0.3 m (24.6±1.0 ft) beyond the microphone target point; and

(C) Microphone location point—a point 15±0.3 m (49.2±1.0 ft) from the microphone target point on a normal to the vehicle path through the microphone target point. Alternately, the microphone location point may be a point 7.5±0.3 m (24.6±1.0 ft) from the microphone target point provided that the sound level reported is adjusted as provided in this appendix under paragraph (d)(3).

(ii) The microphone must be:

(A) Positioned at the microphone location point 1.2±0.1 m (3.9±0.3 ft) above the ground plane; and

(B) Oriented in a plane perpendicular to the vehicle path, and at an angle for which the microphone was calibrated to have the flattest response characteristics over the frequency range of 100 Hz to 10,000 Hz when measured with respect to the motorcycle source.

(iii) The surface of the ground within at least the triangular area formed by the microphone location and the points 15±0.3 m (49.2±1 ft) prior to and 15±0.3 m beyond the microphone target point must be flat (±5 cm (2.0 in)) and level (grade not more than 0.5% along vehicle path), have a concrete or sealed asphalt surface, and be free from snow, soil or other extraneous material.

(iv) The vehicle path must be relatively smooth and of sufficient length for safe acceleration, deceleration and stopping of the motorcycle.

(2) The test site must be a flat, open space free of large sound-reflecting surfaces (other than the ground), such as parked vehicles, signboards, buildings or hillsides located within a 30±0.3 m (98.4±1.0 ft) radius of the microphone location and the following points on the vehicle path (see Figure 1):

(i) The microphone location point;

(ii) A point 15±0.3 m (49.2±1 ft) before the microphone target point; and

(iii) A point 15±0.3 m (49.2±1 ft) beyond the microphone target point.

(c) *Measurement procedure.* (1) The combined weight of the test rider and test equipment used on the motorcycle must not be more than 80 kg (176 lb) nor less than 75 kg (165 lb). Weights shall be placed on the motorcycle saddle behind the rider to compensate for any difference between the actual driver/equipment load and the required 75 kg (165 lb) minimum.

(2) The motorcycle must approach the microphone target point with the throttle fully open and in the highest gear. The motorcycle must start such that maximum speed is reached before the vehicle is within 7.5 m of the microphone target point. The motorcycle must continue along the vehicle path with fully open throttle and at maximum speed past the end point, at which time the throttle must be closed.

(3) If the motorcycle is equipped with an automatic transmission, the procedure of paragraph (1), above, must be followed except that the highest selectable range shall be employed.

(d) *Measurements.* (1) The sound level meter must be set for fast response and for the A-weighting network. The microphone wind screen must be used. The sound level meter must be calibrated with the acoustic calibrator as often as is necessary throughout testing to maintain the accuracy of the measurement system.

(2) The sound level meter must be observed throughout the passby period. The highest noise level obtained for the run must be recorded.

(3) At least three measurements shall be made for each side of the motorcycle. Measurements must be made until at least three readings from each side are within 2 dB of each other. The noise level for each side must be the average of the three. The noise level reported must be for that side of the motorcycle having the highest noise level. If the microphone location point is 7.5 m from the vehicle path as allowed in this appendix under paragraph (b)(1)(i)(c), the noise level must be adjusted by subtracting 6 dB prior to being reported.

(4) While making noise level measurements, not more than one person other than the rider and the observer reading the meter may be within 15 m (49.2 ft) of the vehicle or microphone, and that person must be directly behind the observer reading the meter, on a line through the microphone and the observer.

(5) The ambient sound level (including wind effects) at the test site due to sources other than the motorcycle being measured must be no greater than 60 dB if the microphone is located 15 m from the vehicle path or 66 dB if the microphone is located 7.5 m from the vehicle path as allowed in this appendix under paragraph (b)(1)(i)(c).

(6) Wind speed at the test site during tests must be less than 20 km/h (12.4 mph).

(e) *Required data.* For each valid test, the following data must be recorded:

(1) Motorcycle type, serial number, model year, and date of manufacture.

(2) Names of persons conducting test.

(3) Test location.

(4) Wind speed and ambient noise level measured on the same day as the test and representative of conditions during the test.

(5) Description of the sound level meter including type, serial number, and calibration date.

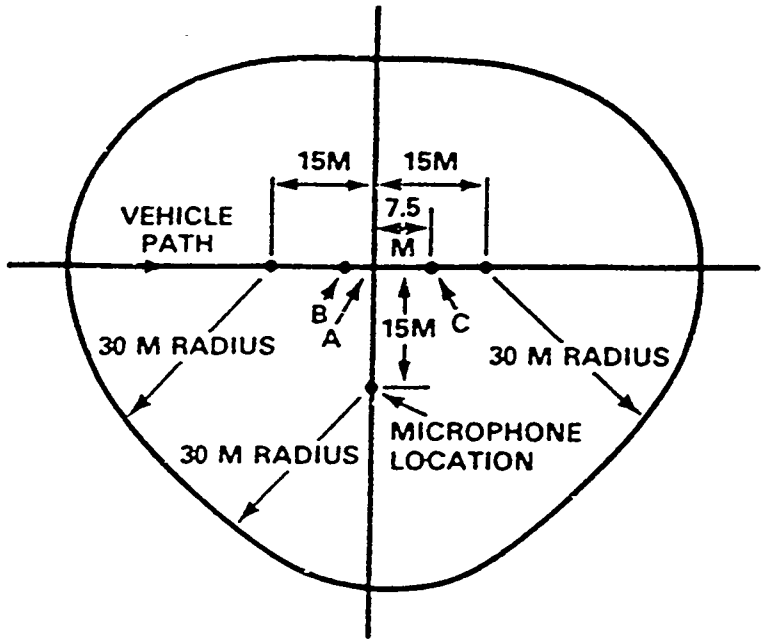
(6) Description of the external acoustic calibrator including type, serial number, and calibration date.

(7) Maximum noise level for each pass on each side of the motorcycle including invalid readings and reasons for invalidation.

(8) Reported noise level.

(9) Other information as appropriate to completely describe testing conditions and procedure.

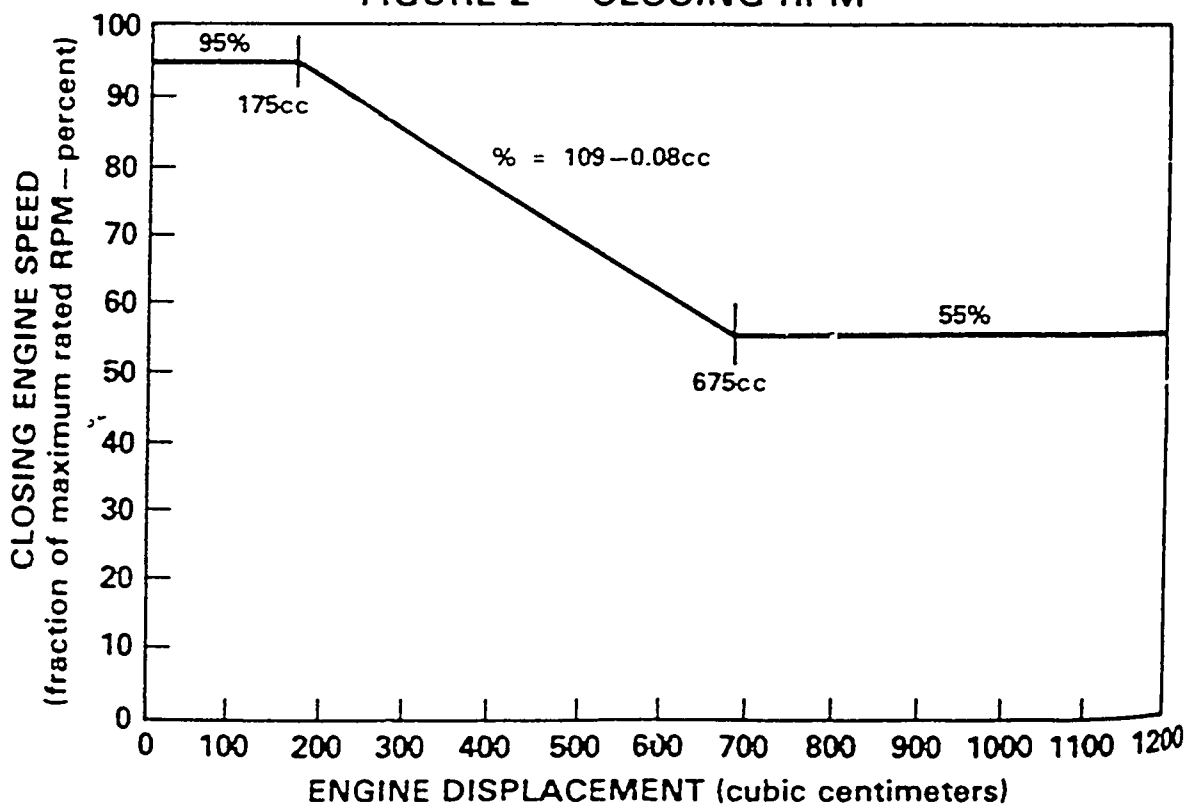
FIGURE 1 — TEST MEASUREMENT AREA



A—MICROPHONE TARGET POINT
B—ACCELERATION POINT (VARIABLE)
C—END POINT

TEST MEASUREMENT AREA

FIGURE 2 — CLOSING RPM



APPENDIX B
SAE Standard J1287

This appendix contains a copy of the SAE standard used in the test; it is reproduced here by permission of the Society of Automotive Engineers, Inc. This standard was current as of the test date. Contact SAE for any revisions. Copies of the current standard are available from SAE: Customer Service Department, Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

MEASUREMENT OF EXHAUST SOUND LEVELS OF STATIONARY MOTORCYCLES—SAE J1287 JUN88 SAE Standard

Report of the Motorcycle Committee, approved June 1980 and completely revised June 1988. Rationale statement available.

1. Scope—This document establishes the test procedure, environment, and instrumentation for determining the sound levels of motorcycles under stationary conditions. This test will measure primarily exhaust noise and does not represent the optimum procedure for evaluating total vehicle noise. For this purpose, SAE J331 or SAE J47 is recommended.

2. Definitions

2.1 Field Calibration—Calibration of the sound level meter using an external sound level calibrator, an internal calibration means, or any other method which will ensure the accuracy of sound level meter readings.

2.2 Longitudinal Plane of Symmetry—As defined in SAE J213a.

2.3 Rated Engine Speed—The engine speed in rpm at which the engine delivers its maximum Net Brake Power as defined in SAE J1349, as determined by the manufacturer.

3. Instrumentation—The following instrumentation shall be used:

3.1 A sound level meter meeting the Type 1, Type S1A, Type 2, or Type S2A requirements of American National Standards Institute Specification for Sound Level Meters, S1.4-1983.

3.1.1 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, provided the system meets the requirements of SAE J184.

3.2 A sound level calibrator with an accuracy of ± 0.5 dB. (See paragraph 6.9.)

3.3 A windscreen which does not affect microphone response more than ± 1 dB for frequencies of 63-4000 Hz and ± 1.5 dB for frequencies of 4000-10 000 Hz.

3.4 An engine speed tachometer or other means of determining engine speed, with a steady state accuracy of ± 3% at the test speed.

3.5 An anemometer with steady state accuracy of ± 10% at 9 m/s (20 mph).

4. Test Site

4.1 The test site shall be a flat, open surface free of large sound reflecting surfaces (other than the ground) such as parked vehicles, signboards, buildings, or hillsides located within 5 m (16 ft) of the motorcycle being tested and the location of the microphone.

4.2 The surface of the ground within the area described in paragraph 4.1 shall be paving or hard packed earth, level within an average slope of 40 mm-m (0.5 in-ft), and shall be free of loose or powdered snow, plowed soil, grass of a height greater than 150 mm (6 in), trees, or other extraneous material.

5. Procedure

5.1 A rider shall sit astride the motorcycle in normal riding position with both feet on the ground. If this is not possible because of the seat height of the motorcycle, and for three-wheeled motorcycles, the rider shall sit in the normal riding position with one or both feet on the footrests. If necessary, an assistant may hold the motorcycle by the forks, front wheel, or handlebars so that it is stationary with its longitudinal plane of symmetry vertical. In the alternative, the rider may use a box, rock, or other object to rest his feet upon to steady the motorcycle, so long as the motorcycle longitudinal plane of symmetry is vertical and stationary.

The rider shall run the engine with the gearbox in neutral at a speed equal to one-half of the rated engine speed.

5.1.1 If no neutral is provided, the motorcycle shall be operated either with the rear wheel (s) at least 50 mm (2 in) clear of the ground or with the drive chain or belt removed, or with the clutch, if the motorcycle is so equipped, disengaged.

5.2 The engine of the motorcycle under test shall be at normal operating temperature during the test.

6. Measurements

6.1 The sound level meter shall be set for the A-weighing network and should be set for slow dynamic response. (See Appendix, paragraph A.5.)

6.2 Tests shall be made on each side of the motorcycle having an exhaust outlet.

6.3 The microphone shall be located behind, 0.5 ± 0.01 m (20 ± ½ in) from, and within 0.01 m (½ in) of the same height as, the exhaust outlet and at a 45 ± 10 deg angle to the normal line of travel of the motorcycle. If there is more than one exhaust outlet per side, the microphone shall be located with reference to the rearmost outlet.

The longitudinal axis of the microphone shall be in a plane parallel to the ground plane. The axis of the microphone shall be oriented as specified for free field response by the manufacturer. (See Fig. 1.)

6.4 No wire or other rigid means of distance measurement shall be attached to the sound measuring system.

6.5 The sound level recorded shall be that measured during steady state operation at the engine speed (± 200 rpm) determined in Section 5 measured on the loudest side of the motorcycle (if outlet located on both sides - see paragraph 6.2). The test speed in rpm shall also be recorded.

6.6 The ambient sound level (including wind effects) at the test site due to sources other than the motorcycle being measured shall be at least 10 dB lower than the sound level produced by the motorcycle under test.

6.7 Wind speed at the test site during the test shall be less than 9 m-s (20 mph).

6.8 While making sound level measurements, not more than one person other than the rider, the measurer, and the assistant (if necessary) (see paragraph 5.1) shall be within 3 m (10 ft) of the motorcycle under test or the microphone, and that person shall be directly behind the measurer on a line through the microphone and the measurer.

6.9 Calibration of the sound level meter using the sound level calibrator (see paragraph 3.2) shall be made immediately before the first test of each test day and should be made at the end of each test day. Field calibration should be made at intervals of no more than 1 h.

7. General Comments

7.1 It is essential that persons conducting the test be knowledgeable of the test procedure and use of the instrumentation.

7.2 Proper use of all test instruments is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to, for both recommended operation of the instrument and precautions to be observed.

7.3 Specific Items for Consideration

7.3.1 The type of microphone, its directional response characteristics, and its orientation relative to the source of sound.

7.3.2 The effects of ambient weather conditions on the performance of all instruments (that is, temperature, humidity, and barometric pressure).

7.3.3 Proper acoustical calibration procedure to include the influence of extension cables, etc.

7.4 Although either Type 1 or Type 2 sound level meters may be used with this procedure, it is suggested that a Type 1 instrument be considered as it generally has lesser overall tolerance which can result in more accurate measurements.

7.5 The use of the word "shall" in the procedure is to be understood as obligatory. The use of the word "should" is to be understood

as advisory. The use of the word "may" is to be understood as permissive.

8. References

8.1 SAE J47 JUN86, Maximum Sound Level Potential for Motorcycles.

8.2 SAE J184 AUG87, Qualifying a Sound Data Acquisition System.

8.3 SAE J213a, Definitions—Motorcycles.

8.4 SAE J331 MAY87, Sound Levels for Motorcycles.

8.5 SAE J1349 JUN85, Engine Power Test Code—Spark Ignition and Diesel.

8.6 ANSI S1.4—1983, Specification for Sound Level Meters.

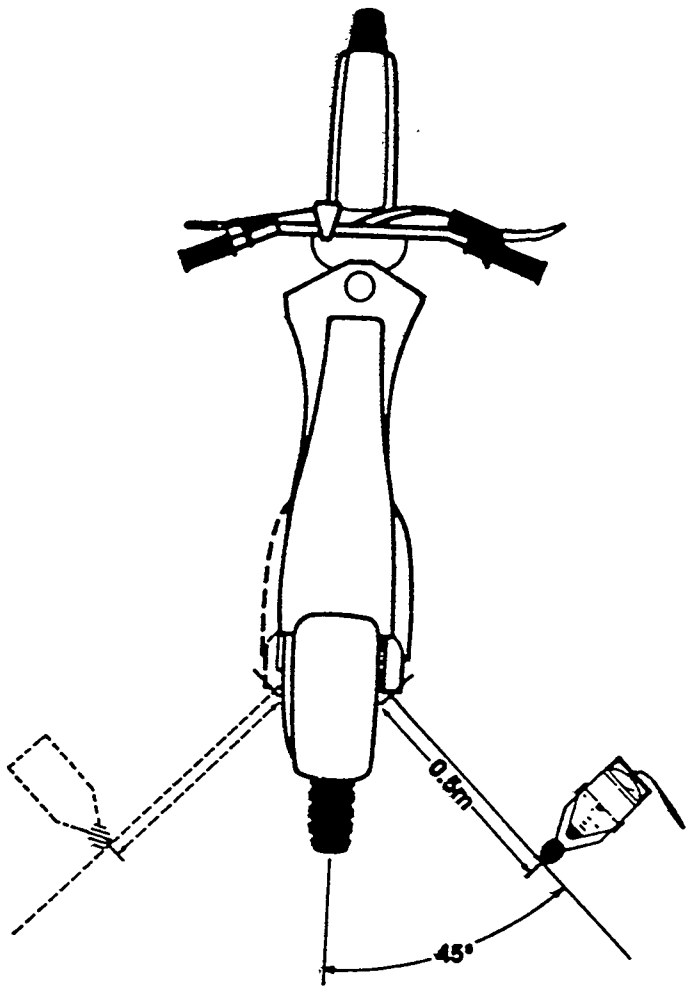


FIG. 1

Appendix

This procedure can be adapted to a variety of uses, which may include exhaust system certification, enforcement of in-use motorcycle standards, and use by motorcycle competition bodies to ensure some silencing of race vehicles. As provided in paragraph 6.1.14 of SAE J1159 JUN86, this Appendix adds supplementary engineering reference data and educational material and is not an integral part of the basic technical report. Accordingly, test results obtained using the variations provided in this Appendix shall be reported with the results of all tests conducted. Such results shall not be reported as having been obtained according to the standard conditions of this document. Some of these uses may require less precision than is called for in the procedure. Accordingly, the following changes may be made for convenience with the realization that accuracy may suffer.

A.1 Enforcement Testing—When used for enforcement, this procedure is intended to be a pass-fail test. A ± 1.5 dB variation due to changes in test conditions, motorcycles, and instruments can occur. Test to test variations within this limit shall be considered acceptable. If limits are to be set according to this procedure, these variations should be considered when limits are chosen.

In enforcement situations, it is often easier to use one-half of the redline speed (redline speed—the lowest numerical engine speed included in the red zone on the motorcycle tachometer), rather than the test speed specified in paragraph 5.1. One-half of redline speed is a higher test speed than one-half of rated rpm; thus the measured sound level will be higher, and a 3 dB tolerance must be added to the applicable sound level limit.

While site tolerances may be relaxed somewhat without serious degradation of precision in the method, site parameters, as described in Section 4, should be as closely adhered to as possible. It is unlikely that useful results will be obtained if, for instance, any other motorcycle or other vehicle or person is within six feet of the test motorcycle, or if the motorcycle is tested while it is loaded in a pickup truck or on a trailer.

A.2 Instrumentation—Type 1 instrumentation, which generally can provide the most accurate measurements, should be used when the need for accuracy is great, such as certification of exhaust systems, or enforcement action which may result in some form of penalty.

Type 2 instrumentation could be appropriate for some enforcement work, such as a preliminary screening test, or for general data gathering. On the other hand, instrumentation which is less precise than Type 1 or Type 2 may be appropriate in cases such as at a racetrack or motorcycle park, when the primary interest is securing some noise reduction from the motorcycles operated within, and not measuring for the purpose of meeting specific maximum noise limits. Selection of equipment should reflect the need for accuracy (particularly considering any consequences) balanced against cost. Caution should be exercised, however, when selecting equipment which does not conform with ANSI standards. Experience with consumer electronic types of sound level meters indicates most such meters do not possess operating characteristics of sufficient accuracy or consistency to yield meaningful results. Meters which meet obsolete ANSI S1.4 Type 3 specifications, however, are sufficiently accurate for less demanding applications such as racetrack enforcement.

A.3 Procedure—When making comparison measurements where a single variable is to be evaluated, such as comparing the sound level of two different exhaust systems on the same vehicle, selection of the correct engine speed according to paragraph 5.1 is not critical as long as the same engine speed is used for each test.

A.4 Racing Motorcycles—This procedure may be used for sound testing of racing motorcycles. An appropriate test speed for both four-stroke and two-stroke high performance competition motorcycles for which the rated engine speed is not known is determined from the formula:

$$\text{Test Speed} = \frac{306\,000}{\text{stroke in mm}} \text{ or } \left(\frac{12\,000}{\text{stroke in in}}\right)$$

A.5 Dynamic Response—Use of slow dynamic response is specified, but fast dynamic response may be used. Because of the essentially constant nature of the sound level, either mode is acceptable; the meter is easier to read when slow response is used.

A.6 Wind Speed—If it is not possible to delay testing until the specified wind conditions prevail, testing can be performed in higher winds. In this case, the motorcycle should be positioned so that the prevailing wind direction is parallel to the normal direction of travel of the motorcycle.

A.7 Alternate Engine Speed—If the rated engine speed for a particular motorcycle is unknown, then the test speed shall be calculated from one of the following formulae:

$$\text{For four-stroke engines: } \frac{250\,000}{\text{stroke in mm}} \text{ or } \left(\frac{9800}{\text{stroke in in}}\right)$$

$$\text{For two-stroke engines: } \frac{200\,000}{\text{stroke in mm}} \text{ or } \left(\frac{7900}{\text{stroke in in}}\right)$$

APPENDIX C
Test Motorcycle Specifications

This appendix contains information on the test motorcycles. Each motorcycle was given a vehicle designator number for purposes of this study.

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 1		*Remarks*
		4 stroke
Engine displacement *(actual)*	591.1 cc	
Engine Redline	6500 rpm	
Rear Tire Diameter	25.94 in	
Rear Tire Circumference	81.5 in	
Primary Drive Ratio	21.88 :1	
Final Drive Ratio	3.429 :1	
Gear Ratio	1.00 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 2		*Remarks*
		4 stroke
Engine displacement *(actual)*	249 cc	
Engine Redline	8000 rpm	
Rear Tire Diameter	25.94 in	
Rear Tire Circumference	81.5 in	
Primary Drive Ratio	3.1 :1	
Final Drive Ratio	3.692 :1	
Gear Ratio	1.941 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 3		*Remarks*
		4 stroke
Engine displacement *(actual)*	99.2 cc	
Engine Redline	9000 rpm	
Rear Tire Diameter	22.04 in	
Rear Tire Circumference	69.25 in	
Primary Drive Ratio	4.438 :1	
Final Drive Ratio	3.571 :1	
Gear Ratio	1.882 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 4		*Remarks*
		2 stroke
Engine displacement *(actual)*	176 cc	
Engine Redline	7000 rpm	
Rear Tire Diameter	25.62 in	
Rear Tire Circumference	80.5 in	
Primary Drive Ratio	3.227 :1	
Final Drive Ratio	3.643 :1	
Gear Ratio	1.933 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 5		*Remarks*
		2 stroke
Engine displacement *(actual)*	198 cc	
Engine Redline	8000 rpm	
Rear Tire Diameter	24.48 in	
Rear Tire Circumference	76.9 in	
Primary Drive Ratio	2.863 :1	
Final Drive Ratio	3.615 :1	
Gear Ratio	2.00 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 6		*Remarks*
		2 stroke
Engine displacement *(actual)*	97 cc	
Engine Redline	7000 rpm	
Rear Tire Diameter	21.43 in	
Rear Tire Circumference	67.3 in	
Primary Drive Ratio	3.895 :1	
Final Drive Ratio	3.429 :1	
Gear Ratio	1.368 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 7		*Remarks*
		4 stroke
Engine displacement *(actual)*	349 cc	
Engine Redline	8000 rpm	
Rear Tire Diameter	25.66 in	
Rear Tire Circumference	80.625 in	
Primary Drive Ratio	2.818 :1	
Final Drive Ratio	3.357 :1	
Gear Ratio	1.733 :1	

EPA F-76 MOTORCYCLE SOUND TEST WORKSHEET		
Vehicle No. 8		*Remarks*
		2 stroke
Engine displacement *(actual)*	246 cc	aftermarket muffler
Engine Redline	8600 rpm	
Rear Tire Diameter	25.5 in	
Rear Tire Circumference	79.5 in	
Primary Drive Ratio	2.555 :1	
Final Drive Ratio	3.285 :1	
Gear Ratio	1.687 :1	

APPENDIX D
Instrument and Test Site Data

This appendix contains information on the instruments used during the test and on test site data—including personnel present and details on sound level meters and recorded ambient conditions.

INSTRUMENT DATA			
Instrument	*Type*	*Serial #*	*Cal Date*
Sound Level Meter	2231 *(channel 1)*	1413405	12/12/91
	2231 *(channel 2)*	1413308	12/12/91
	2232 *(stationary)*	1465590	7/91
Acoustic Calibrator	4230	1411129	12/18/91
Vibrating Reed Tachometer	Treysit		
Anemometer	Dwyer Wind Meter		

TEST SITE DATA

Test Location: Los Alamitos Race Track Parking Lot

Date: 1/14/91

Test Personnel	*Assignment*
Rob Harrison USFS	Test Director USFS
Bill Makel USFS	Date Recorder
Gary Ryder American Honda	Instrument Reader left side
Mike Tyrrell American Honda	Instrument Reader right side
Jeff Shetler Kawasaki	Instrument Reader stationary test
J.C. DeLaney MIC	Test Director MIC
Glenn Parkison Yamaha Consult.	Test Trap Instruments
Ken Bush Suzuki	Tachometer Reader—stationary test
Mike Preston Kawasaki	Test Rider

SOUND LEVEL METERS	
Serial Number	*Time Calibrated*
All	8:45
1465590	11:02
1413308	11:05
1413405	11:07

Time	*Wind Speed*	*Ambient Sound Level*
8:55	2 mph gust 3	
9:15		< 60
11:02	< 2 mph	
11:22		60

APPENDIX E
Measured Sound Levels

This appendix contains the recorded sound levels of each vehicle as measured by the EPA and SAE tests.

MEASURED SOUND LEVELS							
Vehicle Number	*EPA F-76*				*SAE J1287*		*Date: 1/14/92*
	db(A) Left Side	*db(A) Right Side*	*Trap Time (msec)*	*Closing RPM*	*db(A)*	*Test RPM*	*REMARKS*
1	81.8	81.3	165	4011			
1	82.1	81.0	164	4035			
1	81.9	81..2					NG timer malfunction
1	82.1	81.1	161	4111			NG ambient 79
1	82.2	80.6	163	4060			
1	82.0	81.1	161	4111			
1	81.6	80.1	164	4035	87.9	3250	

MEASURED SOUND LEVELS

Vehicle Number	*EPA F-76*				*SAE J1287*		*Date: 1/14/92*
	db(A) Left Side	*db(A) Right Side*	*Trap Time (msec)*	*Closing RPM*	*db(A)*	*Test RPM*	*REMARKS*
2	82.0	81.2	260				NG a little bit fast
2	82.5	81.2	265				NG a little bit fast
2	82.0	80.8	269	7285			
2	81.7	80.8	273	7178			
2	82.0	81.2	275	7126			
2	82.2	81.1	275	7126			
2	82.8	81.1	269	7285			NG outside 1 db range
2	82.2	80.5	273	7178			
2	81.7	79.8	278	7049	83.8	4000	

MEASURED SOUND LEVELS

Vehicle Number	*EPA F-76*				*SAE J1287*		*Date: 1/14/92*
	db(A) Left Side	*db(A) Right Side*	*Trap Time (msec)*	*Closing RPM*	*db(A)*	*Test RPM*	*REMARKS*
3	78.5	78.4	348				NG too fast
	79.0	79.1	364	8527			
	78.3	78.5	368	8434			
	78.4	79.3	370	8388			
	78.4	78.7	368	8434			
	78.7	78.4	361	8597			
	78.5	78.9	359	8645			
					843	4500	

MEASURED SOUND LEVELS

Vehicle Number	*EPA F-76*				*SAE J1287*		*Date: 1/14/92*
	db(A) Left Side	*db(A) Right Side*	*Trap Time (msec)*	*Closing RPM*	*db(A)*	*Test RPM*	*REMARKS*
4	80.6	78.3	304				NG not within 1 db
	82.1	78.6	304	6688			
	81.5	78.9	305	6666			
	81.7	79.2	316				NG too slow
	82.2	79.3	307	6622			
	81.2	79.1	307	6622			
	81.9	79.7	308	6601			
	81.2	78.1	308	6601			
					89.1	3500	

MEASURED SOUND LEVELS

Vehicle Number	EPA F-76				SAE J1287		Date: 1/14/92
	db(A) Left Side	db(A) Right Side	Trap Time (msec)	Closing RPM	db(A)	Test RPM	REMARKS
5	80.4	78.9	277				NG too slow
	80.4	78.1	280				NG too slow
	80.0	77.7					NG timer malfunction
	79.5	78.7	275				NG too slow
	79.7	78.2	267	7257			
	79.6	78.5	267	7257			
	79.6	78.0	269				NG slow
	79.9	77.6	268	7230			
	80.1	78.4	266	7284			
	80.1	78.5	267	7257			
	79.9	78.0	268	7230			
	80.2	78.4	264	7339			
					93.0	4000	

MEASURED SOUND LEVELS

Vehicle Number	EPA F-76				SAE J1287		Date: 1/14/92
	db(A) Left Side	db(A) Right Side	Trap Time (msec)	Closing RPM	db(A)	Test RPM	REMARKS
6	80.9	80.6					NG out of tolerance
	79.1	77.9	310				NG slow
	78.3	77.9	305				Ran in 3rd gear NG slow
	79.2	78.0	294	6650			Ran in 3rd gear
	79.1	78.8	297	6583			Ran in 3rd gear
	79.4	78.0	296	6605			Ran in 3rd gear
	79.2	78.6	298	6561			Ran in 3rd gear
	79.1	77.8	296	6605			Ran in 3rd gear
	78.4	78.6	299	6539			Ran in 3rd gear
					87.0	3500	

MEASURED SOUND LEVELS

Vehicle Number	EPA F-76				SAE J1287		Date: 1/14/92
	db(A) Left Side	db(A) Right Side	Trap Time (msec)	Closing RPM	db(A)	Test RPM	REMARKS
7	80.6	78.5	241				NG slow
	80.7	79.2	234				NG slow
	81.3	79.1	235				NG slow
	81.0	79.7	231	6346			
	80.9	79.4	232	6318			
	81.0	79.7	230	6373			
	80.9	79.5	230	6373			
	81.0	80.0	224	6544			
	80.6	78.8	233	6291			
	81.2	79.8	233	6291			
					86.5	4000	

MEASURED SOUND LEVELS							
Vehicle Number	*EPA F-76*				*SAE J1287*		*Date: 1/14/92*
	db(A) Left Side	*db(A) Right Side*	*Trap Time (msec)*	*Closing RPM*	*db(A)*	*Test RPM*	*REMARKS*
							After market muffler Ran in 2nd gear
8	90.1						Missed reading
	90.8	92.2	206	7663			NG not within 1 db
	90.1	91.7	205	7700			
	90.3	91.0	204	7738			
	89.9	91.2	208	7589			
	90.2	91.9	206	7663			
	89.8	90.1	209	7553			NG not within 1 db
					91.8	4300	11:50 pm finish

RECORDED SOUND LEVELS—4 STROKE			
Vehicle Number	*EPA dB(A)*	*SAE dB(A)*	*Motorcycle Category*
1	81.9	87.9	4
2	82.0	83.8	4
3	78.8	84.3	2
7	80.9	86.5	4

RECORDED SOUND LEVELS—2 STROKE			
Vehicle Number	*EPA dB(A)*	*SAE dB(A)*	*Motorcycle Category*
4	81.7	89.1	3
5	79.9	93.0	3
6	79.1	87.0	1
8	91.5	91.8	3