Grant S809277010

EPA 550/9-82-428

N-96-01
II-A-825

Evaluation of Various Motorcycle Noise Stationary Test Procedures

PRELIMINARY DRAFT
DO NOT QUOTE

July 1982

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CHAPTER I

INTRODUCTION

On December 31, 1980, the United States Environmental Protection Agency (EPA) published a final rule establishing noise emission standards for new manufactured motorcycles and motorcycle exhaust systems (1). Under the regulation beginning January 1, 1983, all newly manufactured street and dual purpose motorcycles (motorcycles designed for either on-road or off-road use) are required to comply with a noise emission standard of 83 dB when tested under the prescribed federal acceleration test procedure which is contained in Appendix A. The federal test procedure, referred to as F76, was developed by modifying the Society of Automotive Engineer's (SAE) test procedure J-331a (2). The procedure measures motorcycle noise emissions under full throttle acceleration at specified percentages of the motorcycle's maximum rated engine speed at a fixed point relative to a microphone location fifty feet to the side of the motorcycle's path. The regulation also requires manufacturers of original equipment and replacement exhaust systems designed and intended for installation on federally regulated motorcycles to certify that their products will not cause those motorcycles to produce noise levels in excess of the new vehicle standard when tested under the F76 procedure.

During the development of this rule the EPA recognized the need for a simple, static noise test procedure which could be used for State and local noise enforcement and for compliance testing by replacement exhaust system manufacturers (3). The EPA further recognized that the usefulness of such a test would depend heavily on the degree to which sound levels obtained under the static test could be related to those obtained under the F76 acceleration test.

As part of its background study, the EPA developed and investigated the possible use of a stationary motorcycle test procedure referred to as F50. The F50 procedure was patterned after an International Standards Organization (ISO) draft standard. It involved running the motorcycle's engine up to fifty percent of its maximum net horsepower rpm, unloaded, and measuring the sound level at a distance of 0.5 meter from the exhaust outlet, on a line displaced 45 degrees from the exhaust axis. Even though their initial evaluation of the test procedure indicated that the correlation between the F50 stationary test and the F76 acceleration test ($r=0.69$, $S_{yx}=3.45$) was not high, the EPA included the F50 test in its proposed rule published on March 15, 1978 (3). However, in response to comments received, many of which questioned the value of the static test based on poor correlation with F76, the EPA dropped the F50 stationary test from the final rule published December 31, 1980.

While the static test was officially dropped from the final regulation, EPA's Noise Enforcement Facility (NEF) continued to investigate means of improving the test, which they hoped to use as a screening test in their compliance auditing program. During the summer of 1980, NEF engineers conducted a battery of tests on 42 motorcycles. The test program sought to improve the correlation between the static F50 test and the F76 acceleration test. The results of the NEF test program indicated that the correlation between the F50 and F76 tests improved when the rpm was accurately controlled, the F76 rpm was used for the stationary test, and the microphone distance was changed from the standard position of 0.5 meter off the exhaust port to 5.0 feet to the side of the motorcycle. The EPA intended to conduct additional tests during the following summer. However, in March 1981 the Reagan Administration announced its plans to phase out the EPA Noise Control Program.

In June of 1980, the Society of Automotive Engineers issued a recommended practice for the measurement of exhaust sound levels of stationary motorcycles, SAE J1287. The procedure, which is essentially identical to the F50 stationary test considered by EPA, is contained in Appendix C.

The purpose of this report is to continue the investigation of ways to improve the correlation between stationary motorcycle noise tests and the federal F76 passby noise test. This report is divided into seven chapters as follows: Introduction, Problem Definition, Research Goals and Objectives, Method, Results, Discussion, Summary and Conclusions. The two principal test procedures, a listing of test vehicles, and a summary of test results are included as appendices.

CHAPTER II

PROBLEM DEFINITION

The data which led EPA to conclude that the correlation between the proposed F50 stationary test and the F76 acceleration test was too poor is shown in Figure 1.(5) As indicated in the figure, the best estimate of the F50 level for a motorcycle with a known F76 passby level of 83 dB is approximately 91 dB. However, due to the variability between the two tests, the degree of which is represented by the standard error of estimate (Syx), the 95% confidence interval for the same motorcycle's F50 level is ± 6.8 dB or (97.9,84.3 dB). In other words, it can be stated with a 95% level of confidence that a motorcycle with a known F76 noise level of 83 dB can be expected to produce an F50 noise level of between 84.3 and 97.9 dB.

If the F50 test was to be used as an enforcement test for determining compliance with the Federal standard of 83 dB under the F76 test, from an enforcement standpoint the standard would have to be set high enough to reasonably assure that a vehicle which fails under the stationary test will likewise fail under the federal acceleration test. For example, based on the data shown in Figure 1, a standard of 98 dB would have to be used in order to guard, at a confidence level of 97.5%, against improperly failing a motorcycle which meets the Federal passby level of 83 dB. In other words, the enforcement officer has to give away

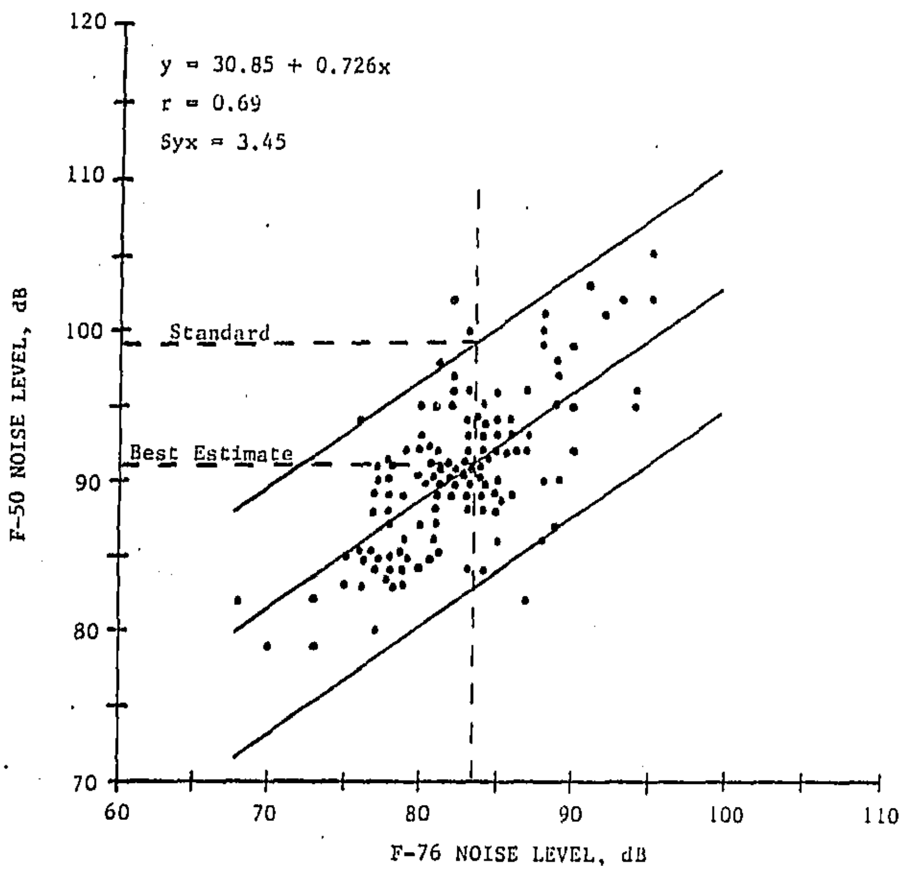

Figure 1. Correlation between F-50 and F-76 tests, 1969-1976 model street and combination street/off-road motorcycles.

7 dB. Under such an approach a large number of motorcycles which exceed the Federal passby standard go undetected.

In order to maximize the capture rate (the percentage of motorcycles exceeding the Federal passby standard which can be properly identified under a stationary test) the standard error of estimate between the stationary and passby test must be minimized.

CHAPTER III

RESEARCH GOALS AND OBJECTIVES

In May 1981, the Environmental Protection Agency awarded a grant to the National Association of Noise Control Officials to carry out motorcycle noise testing. The principal goal of the project was to seek ways to improve the correlation between the SAE J1287 stationary test, which is currently in widespread use, and the Federal F76 passby test. The following objectives were established to assure the achievement of the principal goal:

1. Determine the effect on correlation of running the stationary tests at the F76 passby test rpm, or a percentage thereof, making the stationary test more like the passby test.

2. Determine the effect on correlation of running the stationary test using different degrees of instrumentation sophistication, i.e., sound level meter cutoff at a precisely controlled rpm as opposed to noise measurement in rms slow while using the motorcycle tachometer for engine speed determination.

3. Determine the effect on correlation of running the stationary test with the microphone location shifted from the standard position of 0.5 meter off the exhaust port to 1.5 meters and 3.0 meters from the motorcycle in line with the rear axle.

All of the above modifications were intended to be carried out in the most accurate manner possible, strictly adhering to all test requirements, and using precision laboratory type instrumentation and specially trained professionals.

Since the SAE J1287 stationary test procedure is currently used by enforcement officers in the field under less controlled conditions, a secondary goal for the project was to investigate the degree of accuracy sacrificed under a simplified enforcement procedure by carrying out the following objective:

4. Determine the effect on correlation of running the stationary test on an unprepared site typical of where an enforcement officer might set up, using a hand-held type II general purpose sound level meter to take noise measurements and using the motorcycle tachometer to monitor engine speed.

This simplified enforcement procedure was intended to reflect the correlation between the precise Federal F76 passby test and the SAE J1287 stationary test procedure as it is typically applied by the enforcement community.

CHAPTER IV

METHOD

Fifty-nine street and dual purpose motorcycles were tested to determine their noise emission levels under the Federal F76 acceleration test procedure and a battery of stationary test procedures.

Test Site

Testing was conducted during the period of June 15, 1981, to October 15, 1981, at Eglin Air Force Base, located near Fort Walton Beach, Florida. The test area, as shown in Figure 2, was established on an inactive runway in compliance with F76 minimum test site requirements. The runway was wide enough (40 m) to allow monitoring at the 15 m distance on both sides of the test vehicles during the F76 acceleration test procedure, and sufficiently long (400 m) to allow the test vehicle room to reach the proper approach speed, accelerate past the microphones and decelerate on the other side.

Mobile Noise Laboratory

A specially equipped 1976 Argosy motor home was used as a field laboratory during the project. Most of the test instrumentation was housed in the van which, as shown in Figure 2, was located approximately 60 meters from the test pad.

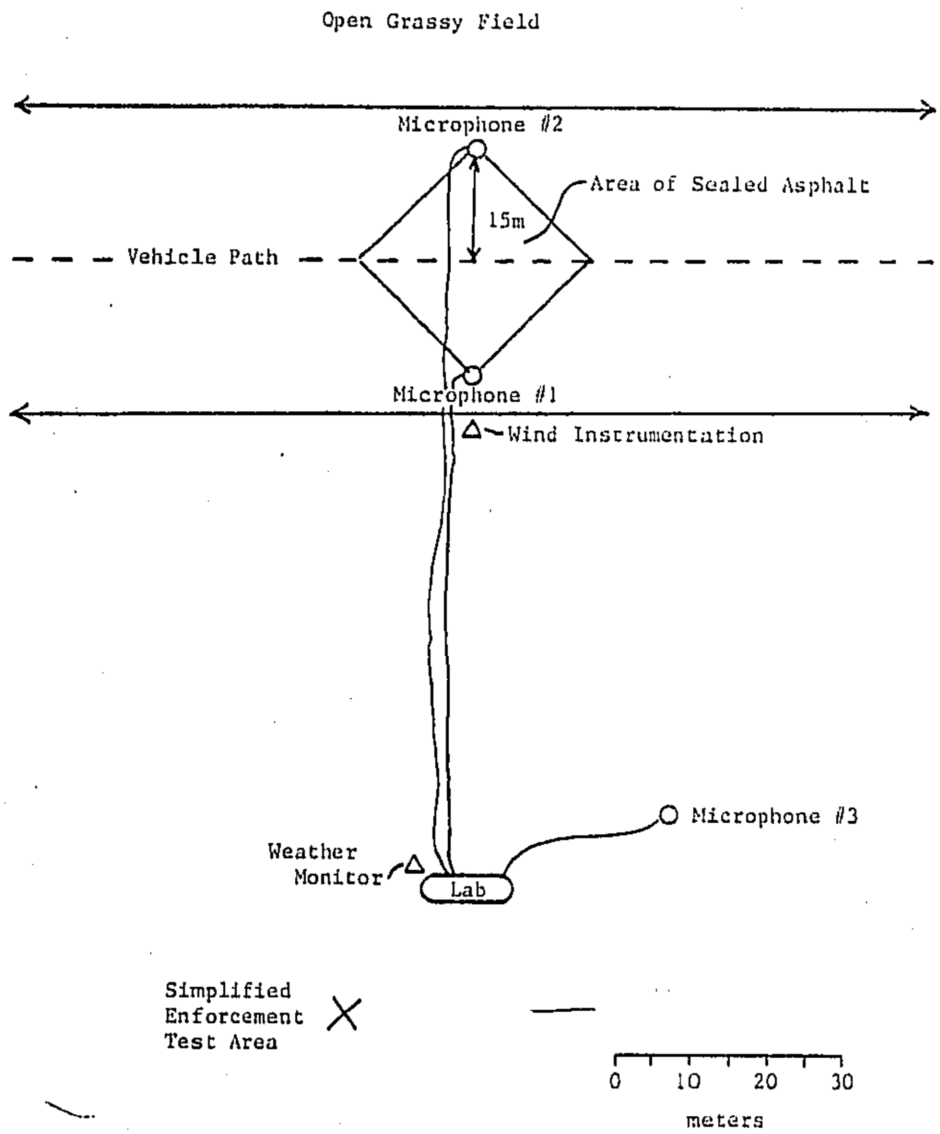

Figure 2. Test Area Layout

Instrumentation

Sound Monitoring Systems

Two different sound monitoring systems were used in the test program.

Precision Sound Measurement Systems

In order to meet the F76 test requirements and ensure the most accurate degree of sound level measurement, a two channel measurement system was used incorporating Bruel and Kjaer (B & K) model 2607 measuring amplifiers in conjunction with B & K model 2804 power supplies, model 2619 preamplifiers and model 4163 microphones. The system had been specifically modified with an SLM cutoff mode added. Under this mode the amplifiers were designed to hold the SPL readings as the engine rpm of the test vehicle reached a preprogrammed level. Traditional rms fast and slow measuring modes were also utilized.

The sound level measurement system was calibrated with an acoustic pistonphone calibrator, B & K model 4220. The calibration was performed immediately before, during and after each day's testing at intervals not exceeding four hours. The system was consistently within ± 0.1 dB of the calibration level. The internal noise of the system was also measured before and after each day's testing at intervals not exceeding eight hours. The noise floor typically ranged from 25 to 35 dB. The frequency response of the system was measured once per week using a B & K model

1023 sine wave generator in conjunction with a B & K model 2305 graphic level recorder. A-weighted and linear frequency sweeps fell consistently within the type 1 tolerances for frequency response specified in the American National Standards Specifications for Sound Level Meters, ANSI S1.4-1971.(6)

General Purpose Sound Level Meter

A Quest model 215 type 2 general purpose sound level meter was used in a set of tests, referred to as simplified enforcement procedures, which were designed to reflect the degree of accuracy which is typically found in enforcement situations. The meter was also used with a remote microphone to monitor background noise levels at microphone position number three during the battery of precision tests.

The meter was calibrated with an acoustic calibrator, Quest model CA-12, before and after each test series at intervals not exceeding four hours. The meter was consistently within ± 0.2 dB of the calibration level.

Engine Speed Monitoring and Control Systems

Ignition Disable System

During the F76 acceleration tests a portable rpm cutoff device was used to automatically disable the test vehicle ignition when a programmed closing rpm was reached. The device, developed by an NEF engineer, was designed to: monitor the test vehicle's engine speed through an inductive pickup placed over a sparkplug wire, shunt the test vehicle's electrical system to ground when the programmed (closing) rpm was reached, thereby acting as a kill switch, and trigger an electronic flash worn on the test driver's belt to assist spotters in visually marking the point at which the test vehicle's ignition system was disabled on the test track. In order to verify that ignition disable did occur at the programed rpm during the acceleration test, the test vehicle operator carried a Nagra model IV-SJ tape recorder to record ignition pulses and the ignition cutoff event during each run. These recordings were later analyzed using a digital storage oscilloscope to verify that the bike was disabled at the desired rpm and to check for stray or missing ignition pulses or other anomalies. The system is shown in Figure 3.

Sound Level Meter Cutoff System

During part of the precision stationary tests, a SLM cutoff device mounted in the mobile noise laboratory was used to: monitor the test vehicle's engine speed and, when the programed rpm was reached, trigger both measurement amplifiers to hold their SPL readings and the digital storage oscilloscope to verify the test rpm and check for any anomalies.

Weather Monitoring Systems

Wind speed and direction (on the test pad), relative humidity, air temperature and barometric pressure were monitored at a weather console located inside the mobile

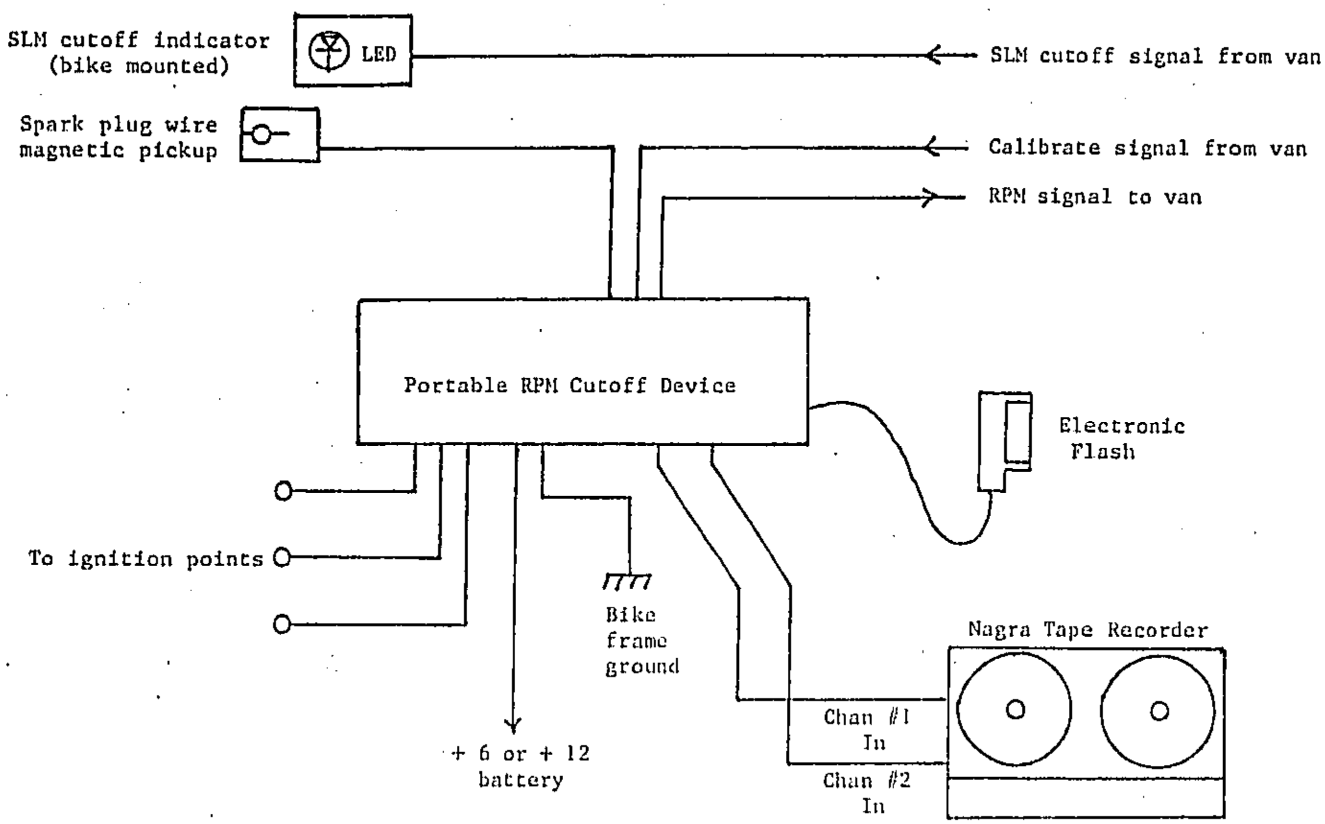

Figure 3. Equipment Configuration On-Board Motorcycle

noise laboratory.

Test Vehicles

Test vehicles were selected to reflect, as closely as possible, the current population of street and dual purpose motorcycles. Table 1 compares the test vehicle population with the U. S. motorcycle population in terms of manufacturer, displacement and age.(7) Test vehicles were obtained primarily from individual owners on a loan basis, with some new motorcycles being provided by local dealers. Motorcycles and exhaust system configurations were chosen to reflect a fairly uniform distribution of sound levels, based on the F76 acceleration test, so that at least five motorcycle emission levels fell within each 5 dB range from 75 to 105 dB. Appendix C contains a listing of test vehicles including information on make, model, year, exhaust system configuration, and the max rated horsepower rpm.

Test Procedures

Each motorcycle was subjected to twenty-two different test procedures including the F76 acceleration procedure, SAE Recommended Practice J1287 and twenty modified SAE J1287 procedures. In each of the twenty modified test procedures one of the following was varied from the standard procedure: sound measurement system, microphone position, or test rpm. The requirements for each test are summarized in Figure 4. In each test the motorcycle's noise emission level was established following the reference procedure.

Table 1

Test Vehicle Sample Compared With U.S. Motorcycle Population

	U.S. Population	Test Sample
Manufacturer		
Honda	39.2%	39.0%
Yamaha	23.1%	28.8%
Kawasaki	14.9%	18.6%
Suzuki	13.3%	10.2%
Harley Davidson	6.3%	3.4%
Other	3.2%	0%
	100.0%	100.0%
Engine Displacement		
On-Highway		
Under 125 cc	6.1%	5.1%
125-349 cc	5.3%	8.5%
350-449 cc	16.4%	13.6%
450-749 cc	14.6%	23.7%
Over 749 cc	22.4%	22.0%
Dual-Purpose		
Under 125 cc	12.8%	6.8%
125-349 cc	18.2%	20.3%
350-449 cc	3.4%	0%
450-749 cc	0.8%	0%
Over 749 cc	0%	0%
	100.0%	100.0%
Model Year		
1982	0%	3.4%
1981	16.4%	25.4%
1980	16.1%	16.9%
1979	15.8%	15.3%
1978	13.3%	8.5%
1977	12.2%	6.8%
1976	8.8%	3.4%
1975	5.3%	6.8%
1974	4.7%	0%
1973	3.9%	8.5%
1972	2.0%	3.4%
1971	0.9%	0%
1970	0.3%	0%
1969	0.1%	1.6%
	100.0%	100.0%

	F76b Passby	Precision Stationary Tests																		Simplified Enforcement Procedure		
Test ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Microphone Distance	15.0m	0.5m						1.5m						3.0m						0.5m		
Microphone Height	1.2m	SAE J1287						12.0cm						24.0cm						SAE J1287		
Microphone Orientation	F76b	SAE J1287						90 from centerline of motorcycle in line with rear axle												SAE J1287		
SLM Type	Specially modified B & K Model 2607 measuring amplifiers in conjunction with precision microphones/reamps, all meeting Type I specifications																			Quest Model 215 Type II SLM		
SLM Response	A	B				C		B				C		B				C		C		
Engine RPM	d	a	b	c	d	a	d	a	b	c	d	a	d	a	b	c	d	a	d	a	c	d
Test ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

NOTES:

SLM Responses

A = RMS Fast Hold
B = Sound Level Meter Cutoff
C = RMS Slow Response

Engine RPM

a = SAE J1287 Test RPM
b = 50% F76b Test RPM
c = 75% F76b Test RPM
d = F76b Test RPM

Figure 4. Summary of Test Requirements

CHAPTER V

RESULTS

Each of the fifty-nine motorcycles was completely tested. A summary of the test results is contained in Appendix D.

In order to evaluate the degree of variability between each of the twenty-one stationary tests and the F76 acceleration test, regression analysis was performed with each stationary test's results regressed on the F76 test results. Table 2 presents a summary of the analysis indicating the correlation coefficient, r, and standard error of estimate, Syx, for each comparison.

Table 2
Summary of Regression Analysis

Test ID	Regressed on F76b r	Syx	Microphone Distance	SLM Type	SLM Response	Engine RPM
1	-	-	15.0m	I	Fast Hold	F76b
2	.89	4.28	0.5m	I	SLM Cutoff	SAE J1287
3	.87	4.33	0.5m	I	SLM Cutoff	50% F76b
4	.91	3.67	0.5m	I	SLM Cutoff	75% F76b
5	.94	3.21	0.5m	I	SLM Cutoff	F76b
6	.88	4.18	0.5m	I	Slow	SAE J1287
7	.94	3.11	0.5m	I	Slow	F76b
8	.88	4.01	1.5m	I	SLM Cutoff	SAE J1287
9	.89	3.59	1.5m	I	SLM Cutoff	50% F76b
10	.94	2.78	1.5m	I	SLM Cutoff	75% F76b
11	.95	2.39	1.5m	I	SLM Cutoff	F76b
12	.87	4.06	1.5m	I	Slow	SAE J1287
13	.94	2.68	1.5m	I	Slow	F76b
14	.88	3.69	3.0m	I	SLM Cutoff	SAE J1287
15	.89	3.59	3.0m	I	SLM Cutoff	50% F76b
16	.94	2.63	3.0m	I	SLM Cutoff	75% F76b
17	.95	2.50	3.0m	I	SLM Cutoff	F76b
18	.89	3.61	3.0m	I	Slow	SAE J1287
19	.95	2.45	3.0m	I	Slow	F76b
20	.90	3.89	0.5m	II	Slow	SAE J1287
21	.92	3.43	0.5m	II	Slow	75% F76b
22	.94	3.23	0.5m	II	Slow	F76b

CHAPTER VI

DISCUSSION

Based on the results presented in Appendix D and summarized in Table 2, each of the original objectives outlined in Chapter III can be addressed. It should be noted that throughout this chapter where references are made to percent reductions in Syx or test variablity, such percent reductions are calculated arithmetically rather than logarithmicaly. For example, a change in Syx from 4.00 dB to 3.00 dB would represent a 25% reduction.

Effect of Test RPM

As shown in Table 3, the correlation between the stationary and passby tests improved when the test rpm was changed. While the standard error of estimate was only reduced 3.8% to 3.84 dB when the 50% F76 test rpm was used, using 75% of the F76 test rpm and the F76 test rpm had significant effects, reducing Syx to 3.03 dB and 2.70 dB and representing reductions of 24.1% and 32.3% over the Syx for the SAE J1287 test rpm.

This improvement in correlation between the passby and stationary tests, based on the use of the F76 test rpm, points to a major conflict between the F76 and SAE J1287 test procedures. Under the F76 procedure the test rpm is established as a percentage of the motorcycle's maximum rated engine speed based on its engine displacement (see Appendix A, Figure 1). For example the test rpm of a

Table 3

Effect of Test rpm and Distance on Syx

(SLM Cutoff Response Only)

Test rpm \ Distance	0.5m	1.5m	3.0m	$\bar{x}_1$
SAE J1287	4.28	4.01	3.69	3.99
50% F76	4.33	3.59	3.59	3.84
75% F76	3.67	2.78	2.63	3.03
F76	3.21	2.39	2.50	2.70
$\bar{x}_2$	3.87	3.19	3.10	

$\bar{x}_1$ = Average Syx for Test rpms over Distances

$\bar{x}_2$ = Average Syx for Distances over Test rpms

Table 4

Effect of Instrument Sophistication on Syx

(SLM Cutoff vs rms Slow)

Test rpm	SLM Response \ Distance	0.5m	1.5m	3.0m	$\bar{x}_3$
SAE J1287	SLM Cutoff	4.28	4.01	3.69	3.99
	rms Slow	4.18	4.06	3.61	3.95
F76	SLM Cutoff	3.21	2.39	2.50	2.70
	rms Slow	3.11	2.68	2.45	2.75

$\bar{x}_3$ = Average Syx for Test rpms and SLM Responses over Distances motorcycle with an engine displacement of less than 175 cc is set at 95% of the motorcycle's maximum rated engine speed, while a motorcyle with an engine displacement greater than 675 cc has a test rpm of 55% of max rated engine speed. The SAE J1287 test procedure sets the test rpm for all motorcycles at 50% of the maximum rated engine speed. These different methods of calculating test rpm appear to contribute greatly to the variability between the F76 and SAE J1287 procedures.

Effect of Instrumentation Sophistication

Under the precision test approach two levels of instrumentation were utilized. The first level involved sound level meter cutoff at a precisely controlled rpm. The second level involved noise measurement in rms slow while using the motorcycle tachometer for engine speed determination. Table 4 compares the two levels of instrumentation for two test rpms and three microphone locations. The two levels of instrumentation appear to measure equally well with no significant differences in Syx noted. It appears that the use of sound level meter cutoff does not significantly reduce the variability between the stationary and passby test results.

Effect of Microphone Location

Shifting the microphone location from the standard position of 0.5 meter off the exhaust port to 1.5 meters and 3.0 meters from the motorcycle in line with the rear axle did tend to minimize the variability between test results. As shown in Table 3, Syx dropped from an average of 3.87 dB at the 0.5 meter microphone distance to 3.19 dB at 1.5 meters and 3.10 dB at 3.0 meters representing reductions of 17.6% and 19.9% in test variability. The higher degree of variation associated with the 0.5 meter location might have been due to the sensitivity of measuring in close proximity to the exhaust port. During the simplified enforcement procedure, where a hand held sound level meter was used to take measurements as opposed to the tripod mounted microphones utilized in the battery of precision tests, the sound pressure level was noted to vary for some motorcycles as the microphone orientation was shifted slightly from the standard displacement of 45 degrees from the exhaust axis.

Effect of Simplified Enforcement Approach

Surprisingly, the simplified enforcement tests proved to be as accurate as the precision tests. Table 5 compares the standard error of estimates for the two precision test procedures and the simplified enforcement procedure for both the SAE J1287 and F76 test rpms. On the average, the simplified enforcement procedure had an Syx of 3.56 dB which represents a 5.1% reduction in variability over the Syx of 3.75 dB for the SLM Cutoff procedure and a 2.5% reduction over the Syx of 3.65 dB for the type I rms slow response measurement procedure. The ability of the type II sound level meter to measure noise on a level equal with type I

Table 5
Effect of Simplified Enforcement Approach on Syx
(0.5 Meter Microphone Distance)

SLM Type	SLM Response	Test rpm / Approach	SAE J1287	F76	$\bar{x}_4$
I	SLM Cutoff	Precision	4.28	3.21	3.75
I	rms Slow	Precision	4.18	3.11	3.65
II	rms Slow	Simplified Enforcement	3.89	3.23	3.56

$\bar{x}_4$ = Average Syx for SLM Types and Responses and Approaches over Test rpms

instrumentation might be explained by the fact that motorcycle exhaust noise is dominant in the 50 Hz to 1000 Hz frequency range (8), where the frequency response requirements for type I and type II meters are most stringent (7).

These results, while not conclusive, suggest that type II sound level meters can be utilized on non-standard sites resulting in approximately the same degree of accuracy achieved with type I instrumentation and standard sites.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The principal goal of the experiment was to investigate ways to improve the correlation, more specifically to reduce the standard error of estimate, between the SAE J1287 stationary test procedure and the Federal F76 passby test procedure. Fifty-nine motorcycles were successfully tested under both procedures, as well as twenty modified stationary test procedures.

Based on the results obtained, running the SAE J1287 test using the F76 test rpm resulted in the greatest reduction in variability between the two tests. The standard error of estimate was reduced approximately 32 percent. Correlation between the stationary and passby tests was also found to improve as the microphone location in the stationary test was shifted from the standard 0.5 meter position to 3.0 meters to the side of the motorcycle, accounting for a 20 percent reduction in test variability. However, use of sophisticated SLM cutoff instrumentation, as opposed to the standard type I measurement system, had no noticeable effect on the test results.

These findings suggest that the correlation between the federal F76 passby test procedure and the SAE J1287 stationary test procedure can be significantly improved. By changing the SAE J1287 test procedure to require use of the F76 test rpm and a microphone location of 3.0 meters, the standard error of estimate can be reduced 41 percent from 4.12 dB to 2.45 dB. Similarly, the 95 percent confidence interval would be reduced from ± 8.2 dB to ± 4.8 dB.

The secondary goal for the experiment was to investigate the degree of accuracy sacrificed under a simplified enforcement procedure.

The results of the experiment suggest that no significant degree of accuracy is lost when the stationary test is conducted using a hand-held type II sound level meter on a non standard site under typical enforcement conditions.

While the results of this experiment are encouraging, additional research is needed to fully document the effects of test rpm, microphone location, and instrument sophistication.

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APPENDIX A

Motorcycle Noise Emission Test Procedure for Street and Off-road Motorcycles

40 CFR Subpart D, Appendix I-1(a)

(Commonly Referred to as F76)

(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 ensure 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 subparagraph (a)(3)(i)(A).

(B) The closing rpm provided it meets the specifications in subparagraphs (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 windscreen which does not affect

microphone response more than ±0.5 dB for frequencies 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.

(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 to 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±1.0 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 A1):

(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 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 A2):

Displacement (cc)	Closing rpm (Fraction of Maximum Rated RPM-Percent)
0-175	95
176-675	109 - 0.08 x (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), above, 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

directions 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 considered 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 reported must be for the 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 displacement, 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.

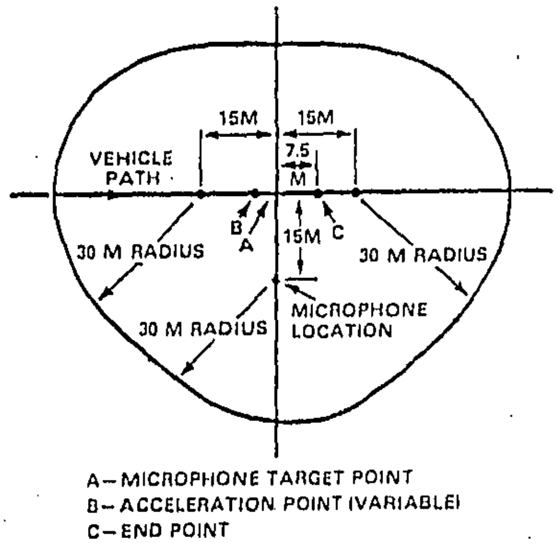

Figure A1. Test Measurement Area

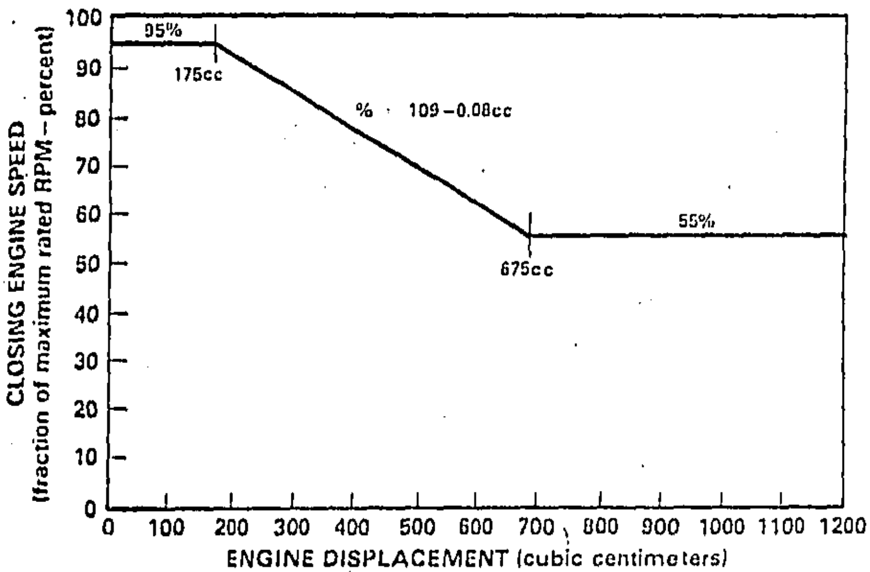

Figure A2. Closing RPM

APPENDIX B

Measurement of Exhaust Sound Levels of Stationary Motorcycles

SAE Recommended Practice - SAE J1287

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, but does not represent the best procedure for evaluating total vehicle noise. For this purpose, SAE Recommended Practice J331a, Sound Levels for Motorcycles, or SAE Recommended Practice J47, Maximum Sound Level Potential for Motorcycles, are recommended.

2. INSTRUMENTATION

The following instrumentation shall be used:

2.1 A sound level meter meeting the Type 1, Type S1A, Type 2, or Type S2A requirements of American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976).

2.1.1 As an alternate 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 sound level recorder or other indicating instrument, providing the system meets the requirements of SAE Recommended Practice J184a, Qualifying a Sound Data Acquisition System.

2.2 A sound level calibrator with an accuracy of ± 0.5 dB. (See paragraph 5.9.)

2.3 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.

2.4 An engine speed tachometer with a steady state accuracy of ±3% at the test speed.

2.5 An anemometer for measuring wind speed, with an accuracy of ±1.5 m/s at 9 m/s (±3 mph at 20 mph).

3. TEST SITE

3.1 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 a 5 m (16 ft) radius of the motorcycle being tested and the location of the microphone.

3.2 The surface of the ground within the area described in paragraph 3.1 should be asphalt, concrete, 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 materials.

4. PROCEDURE

4.1 The rider shall sit astride the motorcycle in normal riding position with both feet on the ground and run the engine with the gearbox in neutral at a speed equal to one-half of the speed at which the engine develops maximum rated net power. (See SAE Recommended Practice J245, Engine Rating Code-Spark Ignition.) If no such speed is published for the particular motorcycle, then the test speed shall be calculated from one of the following formulae:

For four-stroke engines:

250,000/stroke in millimeters or

(9,800/stroke in inches)

For two-stroke engines:

200,000/stroke in millimeters or

(7,900/stroke in inches)

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

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

5. MEASUREMENTS

5.1 The sound level meter shall be set for the A-weighting network and should be set for slow dynamic response. (See Appendix, paragraph A.6.)

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

5.3 The microphone shall be located behind, 0.5 ± 0.01 m (20 ± 1/2 in) from, and within 0.01 m (1/2 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.

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

5.5 The sound level recorded shall be that measured during steady state operation at the engine speed (± 200 rpm) determined in Section 4, measured on the loudest side of the motorcycle. The test speed in rpm shall be recorded.

5.6 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.

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

5.8 While making sound level measurements, not more than one person other than the rider and the measurer 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.

5.9 Acoustic calibration of the sound level meter 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 hour.

6. GENERAL COMMENTS

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

6.2 Proper use of all test instrumentation is essential to obtaining valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operations of the instrument and precautions to be observed.

6.3 Specific items for consideration:

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

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

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

6.4 Although either Type 1 or Type 2 sound level meters shall 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.

6.5 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.

7. REFERENCES

1. SAE J331a, Sound Levels for Motorcycles.
2. SAE J47, Maximum Sound Level Potential for Motorcycles.

3. ANSI S1.4-1971 (R1976), Specification for Sound Level Meters.

4. SAE J184a, Qualifying a Sound Data Acquisition System.

5. SAE J245, Engine Rating Code-Spark Ignition.

APPENDIX C

Listing of Test Vehicles

Note: OEM = Original Equipment Manufacture

Vehicle Number	Make	Model	Year	Exhaust System Configuration	Max Rated HP rpm
1	Kawasaki	KE 175	1978	OEM	7000
2	Honda	CB 360	1975	Aftermarket	8500
3	Honda	CB 750	1981	OEM	9000
4	Yamaha	XS 500D	1977	Aftermarket	8500
5	Honda	CB 750E	1969	Aftermarket	8000
6	Honda	CB 400T	1978	OEM	9500
7	Kawasaki	KZ 250D	1981	OEM	8000
8	Yamaha	XS 650H	1981	OEM	7500
9	Harley Davidson	XLH 1000	1981	Aftermarket	5800
10	Suzuki	TS 185	1973	OEM	7000
11	Kawasaki	KZ 550A	1980	Aftermarket - Baffle Removed	8500
12	Honda	XL 250S	1981	OEM	7500
13	Kawasaki	KZ 400	1975	Modified - Mufflers Removed	8500
14	Honda	GL 1100	1981	OEM	7500
15	Honda	XL 185S	1979	OEM	8000

Vehicle Number	Make	Model	Year	Exhaust System Configuration	Max Rated HP rpm
16	Honda	CB 900C	1980	OEM	8500
17	Honda	CB 650	1979	OEM	9000
18	Yamaha	XT 250H	1981	OEM	8000
19	Yamaha	RD 350B	1975	Modified OEM - Baffles Removed	7500
20	Honda	CB 750A	1977	OEM	7500
21	Suzuki	GS 250T	1980	OEM	10000
22	Yamaha	XS 400D	1977	OEM	9000
23	Honda	CX 500D	1979	OEM	9000
24	Honda	CB 450	1973	Modified - Mufflers Removed	8500
25	Honda	CB 450	1973	OEM	8500
26	Suzuki	GN 400X	1980	OEM	7500
27	Yamaha	XS 750 SE	1979	Mod. Aftermarket - Baffle Removed	9000
28	Honda	CB 350	1973	Aftermarket	9000
29	Yamaha	SR 250G	1980	OEM	8000
30	Harley Davidson	SX 125	1973	OEM	6750

Vehicle Number	Make	Model	Year	Exhaust System Configuration	Max Rated HP rpm
31	Honda	CL 175	1972	Modified OEM - Baffle Removed	10000
32	Honda	CL 175	1972	Modified OEM	10000
33	Honda	XL 125S	1979	Mod. Aftermarket - Baffle Removed	9500
34	Honda	XL 125S	1979	Aftermarket	9500
35	Kawasaki	KL 250	1980	Modified - Muffler Removed	8500
36	Yamaha	DT 175F	1979	Aftermarket	7000
37	Yamaha	RD 125	1975	OEM	9500
38	Honda	CB 125S	1980	OEM	10000
39	Kawasaki	KH 100	1976	OEM	7500
40	Honda	CB 900C	1981	OEM	8500
41	Kawasaki	KZ 1000CTD	1977	Modified OEM	8000
42	Suzuki	GS 750	1980	OEM	9000
43	Suzuki	GS 1000E	1979	Mod. Aftermarket - Baffle Removed	8000
44	Honda	GL 1000LTD	1976	OEM	7500
45	Kawasaki	KZ 440	1980	OEM	8500

Vehicle Number	Make	Model	Year	Exhaust System Configuration	Max Rated HP rpm
46	Yamaha	XJ 550RH	1981	OEM	9000
47	Suzuki	GS 550L	1981	OEM	9000
48	Yamaha	DT 80H	1981	Modified OEM - Spark Arrestor Removed	7000
49	Yamaha	DT 80H	1981	OEM	7000
50	Yamaha	DT 100H	1981	OEM	7000
51	Yamaha	DT 100H	1981	Modified OEM - Spark Arrestor Removed	7000
52	Yamaha	XV 920RH	1981	OEM	7000
53	Honda	MB 50C	1982	Modified OEM - Baffle Removed	9000
54	Honda	MB 50C	1982	OEM	9000
55	Kawasaki	KZ 650D	1979	OEM	8000
56	Kawasaki	KZ 550A	1980	Aftermarket	8500
57	Yamaha	SR 500	1978	OEM	7000
58	Yamaha	SR 500	1978	Modified - Muffler Removed	7000
59	Kawasaki	KZ 650D	1979	Aftermarket	8000

APPENDIX D

Summary Of Test Results

Test ID \ Vehicle	1	2	3	4	5	6	7	8
1	78.8	92.0	77.7	92.8	87.9	82.2	82.1	78.3
2	82.8	100.8	89.8	101.0	107.6	90.2	87.0	93.6
3	81.9	96.8	85.4	88.8	97.9	87.2	86.1	85.9
4	89.8	103.3	87.7	98.5	103.0	92.3	91.7	92.2
5	98.1	110.4	91.8	105.8	108.0	99.2	101.2	95.8
6	82.8	102.6	89.8	98.6	108.1	90.5	88.3	95.0
7	97.8	111.0	91.0	106.5	108.0	99.4	100.5	97.8
8	80.5	94.0	88.9	94.2	100.1	88.1	81.8	88.9
9	79.5	89.8	81.8	86.2	90.1	84.9	80.3	80.5
10	87.5	97.6	85.0	94.2	96.3	90.3	88.3	87.4
11	96.0	105.1	91.4	101.3	102.2	98.3	97.2	91.6
12	78.8	95.3	87.0	93.8	100.8	88.5	83.5	90.8
13	95.7	105.0	89.5	101.2	102.3	97.2	96.5	93.6
14	75.7	88.0	83.5	88.3	93.4	81.9	77.0	83.5
15	74.0	82.6	75.6	80.0	83.4	77.7	77.3	73.7
16	82.8	91.2	78.9	89.4	89.7	83.3	84.4	81.9
17	91.0	99.0	87.3	95.8	94.8	90.5	93.0	85.0
18	74.3	89.8	81.6	87.3	94.0	81.5	77.5	85.2
19	91.4	98.3	84.0	95.6	95.7	90.5	90.5	86.9
20	82	102	90	102	106	92	88	96
21	89	105	88	102	101	94	93	94
22	97	111	91	107	107	100	102	97

Test ID \ Vehicle	9	10	11	12	13	14	15	16
1	93.4	83.8	99.6	81.5	99.7	77.3	79.8	78.0
2	104.6	92.0	113.0	84.6	109.1	93.4	82.5	89.0
3	96.3	91.2	106.1	84.1	104.3	89.4	81.8	85.5
4	100.0	95.1	110.5	88.0	114.1	89.8	88.9	87.8
5	105.3	100.2	114.3	94.5	116.9	94.7	95.9	90.9
6	105.8	90.8	111.2	85.2	111.0	92.7	82.2	89.8
7	106.0	102.0	115.5	93.5	118.0	94.4	96.7	91.0
8	99.4	88.8	108.5	83.8	103.4	88.6	79.4	85.5
9	92.2	88.4	102.6	83.2	101.2	82.9	78.7	80.0
10	95.7	92.4	106.1	87.4	108.4	84.6	87.0	84.7
11	102.5	96.8	110.7	92.5	112.1	89.8	94.2	88.4
12	99.9	87.6	106.4	85.3	102.0	88.0	80.0	87.2
13	101.5	99.0	108.3	92.1	110.0	89.6	94.2	88.6
14	91.8	82.1	100.5	78.2	95.1	82.6	74.5	81.2
15	83.7	81.3	94.5	77.2	94.5	76.9	73.0	75.2
16	88.6	86.3	99.6	81.9	101.6	79.2	80.9	79.0
17	93.8	91.8	105.0	86.5	105.8	83.8	88.5	82.4
18	91.4	82.3	99.8	79.2	96.4	82.1	75.0	81.3
19	94.5	94.8	102.8	87.3	103.6	83.6	89.0	83.7
20	104	92	108	85	108	93	82	89
21	101	97	107	88	115	89	89	89
22	107	101	113	93	118	95	96	91

Test ID \ Vehicle	17	18	19	20	21	22	23	24
1	77.8	79.8	97.8	77.1	84.2	83.9	80.2	104.5
2	91.7	85.6	113.6	90.5	89.7	100.2	90.0	113.9
3	82.4	84.7	112.1	83.3	88.7	95.1	88.8	109.3
4	88.4	90.3	114.9	87.4	96.9	100.7	89.9	115.4
5	93.9	96.3	118.0	91.9	99.9	103.3	92.3	122.1
6	89.0	84.2	112.2	91.3	90.2	96.9	90.4	113.8
7	92.0	95.6	116.4	92.0	102.7	103.2	91.6	122.2
8	87.4	83.3	107.6	88.0	87.4	92.7	86.8	108.9
9	78.4	81.7	105.6	80.1	85.8	87.8	84.6	102.8
10	85.1	87.6	108.6	84.1	94.1	94.9	87.0	108.9
11	91.0	93.4	112.4	88.9	100.7	98.9	89.6	116.3
12	87.8	82.8	106.8	87.2	87.6	92.6	86.2	107.0
13	89.4	93.8	112.0	89.0	91.4	99.2	89.2	116.0
14	82.0	77.8	102.5	81.2	80.4	86.2	81.0	102.6
15	71.9	75.9	99.2	73.5	78.9	83.9	78.7	96.7
16	77.5	83.1	102.1	78.5	88.8	88.4	82.2	101.6
17	84.3	89.2	106.4	83.2	93.8	92.3	85.4	109.0
18	81.8	77.8	102.2	80.8	81.2	85.7	80.9	100.0
19	84.0	90.0	106.0	83.5	95.0	92.6	84.2	109.5
20	89	85	113	89	90	97	90	113
21	87	88	115	86	96	100	90	114
22	94	97	117	90	102	104	92	121

Test ID \ Vehicle	25	26	27	28	29	30	31	32
1	86.2	79.0	103.8	92.7	80.7	79.2	98.9	93.0
2	91.1	88.4	112.8	101.3	86.8	85.0	106.7	99.2
3	87.2	83.3	104.5	97.3	85.6	82.2	105.3	97.7
4	92.5	89.6	108.6	105.6	92.6	89.2	112.0	105.4
5	99.2	99.7	116.5	110.6	98.8	94.7	117.4	112.7
6	91.5	88.4	112.5	99.9	87.3	82.2	105.3	99.2
7	99.1	99.0	115.5	111.8	99.5	94.0	118.3	113.4
8	88.7	83.2	106.7	93.2	82.3	78.9	102.0	94.6
9	84.0	80.0	101.2	92.2	81.7	79.8	101.1	93.2
10	89.7	85.3	105.7	98.6	88.7	85.8	108.2	99.5
11	95.7	97.8	113.1	103.4	93.8	92.0	110.3	105.4
12	88.5	83.7	110.7	93.2	83.6	80.0	102.0	94.2
13	96.2	98.0	112.0	104.8	96.2	92.4	111.4	104.8
14	81.9	77.9	100.2	87.6	78.0	72.6	96.6	88.5
15	77.5	74.0	94.2	86.0	76.2	73.0	95.1	87.7
16	83.2	81.3	100.9	93.3	85.7	80.3	102.3	94.4
17	89.3	89.6	107.8	99.9	89.6	86.8	106.0	100.2
18	82.3	78.0	103.6	88.2	77.6	74.2	95.6	87.8
19	89.8	90.0	105.8	99.0	90.2	86.8	105.6	99.8
20	91	87	113	101	87	85	105	98
21	93	90	106	105	92	91	115	106
22	99	100	115	112	100	95	119	115

Test ID \ Vehicle	33	34	35	36	37	38	39	40
1	102.8	88.4	87.5	84.8	83.3	83.0	79.3	77.7
2	108.5	100.5	95.5	96.2	98.3	84.8	87.3	90.6
3	110.0	100.4	93.5	95.6	98.2	83.6	85.7	85.7
4	120.6	107.1	100.5	99.3	101.9	92.5	92.9	88.6
5	124.8	111.2	109.5	100.5	105.3	97.5	97.0	91.5
6	107.3	99.5	94.4	96.6	98.7	84.7	85.2	91.1
7	123.2	110.5	108.7	101.6	104.2	97.6	96.9	91.7
8	101.6	94.2	89.0	90.0	93.0	81.6	81.0	86.9
9	102.7	94.6	86.0	89.5	91.8	81.0	79.8	82.0
10	112.0	99.9	93.4	92.7	96.8	88.5	86.8	85.4
11	117.4	102.5	101.5	96.8	99.9	95.4	93.3	89.0
12	102.0	102.8	87.3	88.5	92.6	80.8	79.5	87.3
13	113.4	93.5	101.8	95.4	99.9	94.8	93.6	89.2
14	96.9	88.2	83.2	83.8	86.8	76.9	76.8	81.2
15	98.3	88.4	81.5	83.9	86.5	75.6	74.7	75.7
16	105.7	93.2	88.2	86.7	90.4	83.6	82.3	79.7
17	109.5	99.8	96.9	92.5	94.9	89.3	86.6	83.4
18	96.3	87.5	83.6	82.4	86.9	77.2	75.8	81.8
19	108.0	98.1	97.4	90.4	94.0	90.2	87.2	83.6
20	109	100	94	96	99	86	85	90
21	121	105	96	97	102	93	92	90
22	126	111	109	100	104	99	97	92

Vehicle / Test ID	41	42	43	44	45	46	47	48
1	86.0	78.6	101.7	76.1	77.9	76.8	80.0	86.0
2	102.9	91.6	114.0	88.1	87.2	90.5	97.0	102.3
3	93.6	83.6	100.6	81.0	84.0	81.9	93.4	101.4
4	101.0	89.7	107.4	85.0	89.9	89.9	96.7	104.6
5	106.1	94.0	112.4	89.9	94.9	93.8	99.2	107.2
6	104.7	91.4	112.2	87.2	87.7	88.2	96.4	101.4
7	106.8	92.8	112.2	89.8	93.6	93.8	98.8	105.5
8	99.0	88.6	108.9	86.1	83.5	87.5	93.6	98.8
9	87.5	79.7	95.7	77.2	79.1	79.5	89.3	98.6
10	94.9	86.6	103.5	83.1	86.6	87.7	93.1	99.7
11	101.5	90.7	109.8	88.2	92.4	92.6	94.3	101.5
12	98.8	88.6	107.3	85.6	82.6	86.8	92.8	98.3
13	102.4	91.2	108.5	87.7	90.1	92.8	94.6	100.0
14	91.6	83.4	100.2	81.5	78.6	82.4	87.2	91.6
15	82.0	74.2	89.3	73.2	73.4	74.3	83.4	92.6
16	88.8	80.9	96.7	78.6	80.7	82.0	86.9	93.2
17	95.2	86.0	102.1	84.3	86.4	85.8	88.5	94.5
18	92.7	83.0	101.4	80.7	78.5	81.9	86.8	91.8
19	95.7	86.0	102.3	82.5	85.3	86.2	89.2	92.6
20	104	91	110	87	87	89	97	99
21	100	90	106	85	90	89	96	101
22	107	93	111	89	94	94	99	103

Test ID \ Vehicle	49	50	51	52	53	54	55	56
1	77.1	79.0	86.0	78.8	88.9	78.1	78.1	90.9
2	93.6	92.1	101.9	91.2	106.1	83.0	89.4	99.1
3	92.1	92.9	100.2	85.2	105.5	82.1	86.4	92.6
4	95.3	94.8	102.5	89.6	109.4	90.5	87.9	99.4
5	98.8	98.8	104.8	91.9	111.5	93.3	90.8	104.9
6	92.4	91.8	98.6	91.1	103.3	92.0	89.5	99.6
7	97.4	96.8	103.4	91.4	110.0	91.8	90.8	105.9
8	87.0	86.2	94.7	87.2	101.3	80.5	87.5	95.4
9	85.3	86.5	93.2	81.0	100.1	79.6	81.5	90.0
10	87.6	88.9	96.5	85.2	103.3	86.9	85.6	95.0
11	90.6	91.2	98.2	88.1	105.8	90.9	88.9	100.1
12	84.8	84.4	92.3	86.1	98.9	79.5	86.7	95.5
13	88.8	89.7	96.4	87.9	103.0	89.4	88.4	100.0
14	79.6	80.7	88.0	81.3	94.6	74.7	81.9	90.3
15	79.1	79.3	87.5	75.1	94.1	73.2	75.8	84.3
16	81.3	82.5	89.4	79.5	97.8	80.9	79.8	89.6
17	84.9	85.3	92.4	83.4	101.2	85.5	83.6	92.0
18	79.0	78.4	86.0	80.8	92.6	74.4	81.4	87.8
19	83.8	83.0	90.5	82.3	97.8	85.4	83.6	94.3
20	91	89	97	91	102	82	89	99
21	93	92	99	89	106	88	88	98
22	96	95	103	92	108	93	91	105

Test ID \ Vehicle	57	58	59					
1	81.9	101.7	80.9					
2	90.7	114.6	90.0					
3	87.6	109.8	87.0					
4	89.4	113.5	89.2					
5	95.4.	117.3	91.9					
6	90.0	112.2	91.0					
7	95.1	117.2	91.3					
8	86.7	106.4	87.6					
9	82.3	101.0	82.6					
10	85.3	105.2	86.0					
11	92.2	110.0	89.4					
12	85.9	104.6	87.2					
13	92.2	110.4	88.8					
14	79.5	99.8	82.3					
15	77.1	94.3	77.0					
16	80.2	99.8	80.9					
17	87.4	104.9	84.2					
18	79.4	98.3	82.3					
19	87.3	104.7	83.2					
20	90	111	91					
21	91	112	88					
22	96	117	92					