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An Evaluation and Assessment of Existing Data and Procedures for the Measurement of Noise from Motorcycles

Applied Acoustics Section
Institute for Basic Standards
National Bureau of Standards
Washington, D. C. 20234

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Final Report

Prepared for
**Office of Noise Abatement and Control
U.S. Environmental Protection Agency
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EXECUTIVE SUMMARY

The Environmental Protection Agency (EPA) is charged with taking strong, comprehensive action to protect public health and welfare from increasing noise. Accordingly, the Agency initially identified medium and heavy trucks and portable air compressors as major noise sources and promulgated noise emission regulations covering these products. Additional products have recently been identified as major noise sources, including motorcycles. For the purposes of this discussion motorcycles can be defined as two or three wheeled vehicles (excluding tractors) with a propelling engine and a seat or saddle for the use of the operator.

Motorcycle noise can be categorized as the noise produced by the power plant (including the engine, transmission, intake, exhaust, etc.) and by aerodynamic flow and tire-road interaction. The noise from the power plant increases as the engine speed (and power) increases while the noise from aerodynamic flow/tires increases as the vehicle speed increases. Maximum power-plant noise usually occurs when the engine is delivering maximum power at its maximum operating speed. The percentage of time a motorcycle spends at maximum noise conditions is determined by the vehicles power-to-weight ratio and operating conditions such as acceleration, speed, load (weight of operator), and to a great extent, the manner in which the motorcycle is operated.

This report reviews existing motorcycle noise measurement procedures with regard to their usefulness in the regulation of motorcycle noise as well as the availability, extent and applicability of existing data. On the basis of this review, the following probable or potential measurement difficulties have been identified that could hinder promulgation and/or enforcement of future EPA regulations to control the noise emission from motorcycles.

- AN INSUFFICIENT DATA BASE. Data exist in only limited quantity in the public domain on the noise levels associated with motorcycle operations.

- NEED TO DETERMINE QUANTITY TO BE REGULATED. Need to develop a philosophy regarding the quantity to be regulated, i.e., maximum noise potential, maximum noise under normal operating conditions, or average noise. If average noise is selected, there is the need to develop a typical operating cycle.

- LACK OF TYPICAL USAGE DATA. In order to develop an appropriate, reliable and repeatable test procedure, it is necessary to consider the range of possible motorcycle operational modes and the noise emission associated with each mode. What is needed is definition of the percentage of time which a motorcycle typically spends accelerating, decelerating, at low speed cruise, at high speed cruise, at wide open throttle, etc. Such data could serve as the basis for logical decisions on whether a multi-modal test procedure or simply a few selected modes of operation should be specified as part of the test procedure. Such typical usage data do not presently exist for motorcycles.

- NEED TO DEVELOP AN OPERATOR-AT-EAR NOISE TEST. There exists a need to develop an operator-at-ear noise test to assess potential hearing impairment that may be incurred by the operator.

- NEED TO ACCOUNT FOR ENVIRONMENTAL/SITE EFFECTS. There is a need for the various environmental and test site effects on noise generation, radiation and/or propagation to be systematically investigated and correction factors developed so that measurements made under any conditions may be corrected to a single standard set of conditions. If correction factors are feasible then there is a need for a site calibration procedure or definition of limiting test conditions.

- NEED FOR SIMPLER TEST PROCEDURE. There exists a need to develop a test procedure that is simpler to perform and is less dependent on weather and test site variables than those specified in current standards. Correlation should be established between the results obtained utilizing such a test and human response to motorcycle noise.

- A NEED TO BETTER SPECIFY TRANSIENT RESPONSE OF INSTRUMENTATION. There exists a need to evaluate the response of existing instrumentation to actual transient signals, e.g., a motorcycle passby, in order to establish the relationships among the various precision instruments, to supply data to strengthen existing standards, and to establish a data base so that the technical community, manufacturers, lawmakers and enforcement agencies will have a common basis for comparison of results obtained using supposedly comparable equipment.

In summary, it is doubtful that the data in the open literature are extensive enough to provide EPA with the information needed for a comprehensive analysis of the economic costs and technical feasibility associated with a given regulation. Furthermore, there are insufficient data available upon which to base an evaluation of alternative motorcycle noise measurement procedures or to establish correlations between the noise associated with various operational modes and the noise measured utilizing various test procedures.

Thus, it appears that EPA will have to generate a rather extensive physical data base and investigate alternative measurement procedures prior to formulation of the Notice of Proposed Rule Making.

AN EVALUATION AND ASSESSMENT OF EXISTING DATA AND PROCEDURES FOR THE MEASUREMENT OF NOISE FROM MOTORCYCLES

This report reviews existing motorcycle noise measurement procedures with regard to their usefulness in the regulation of motorcycle noise as well as the availability, extent and applicability of existing data. On the basis of this review, probable or potential measurement difficulties are identified that could hinder the promulgation and/or enforcement of future EPA regulations to control the noise emission from motorcycles.

Key Words: Acoustics (sound); measurement methodology; motorcycle; noise emission standard; noise measurement.

1. Introduction and Scope

The National Bureau of Standards (NBS), under the sponsorship of the Office of Noise Abatement and Control (ONAC), U. S. Environmental Protection Agency (EPA), has attempted in this report to identify probable or potential measurement difficulties that could hinder the promulgation and/or enforcement of future noise regulations to control the noise emissions from motorcycles. A search of the open literature in conjunction with numerous industrial and private sector contacts established the basis for discussion of:

1. The basic characteristics of motorcycle design and construction.

2. The effects of motorcycle noise and the parties affected.

3. The major component noise sources for motorcycles.

4. The normal or typical modes of operation characteristic of the various classes of motorcycles.

5. The usefulness of existing measurement procedures for use in regulation of the noise from motorcycles, considering the viewpoint of EPA, manufacturers and enforcement personnel.

6. The availability, extent and applicability of existing data that could be utilized by EPA in their efforts to promulgate noise emission regulations for motorcycles.

This report is limited to those factors related to the measurement of motorcycle noise. EPA/ONAC will independently investigate the technical feasibility and economic implications of motorcycle noise regulation. Also, it is assumed that the strategy followed during the development of the new truck regulation -- namely, that tires will be identified separately as a major noise source -- will apply to all vehicular noise sources, therefore, this report concentrates on procedures for measuring the noise of motorcycles, excluding tires.

One factor which makes detailed discussion of this source unique and more difficult than for other vehicle noise sources is the extreme state of flux of the motorcycle field in general. This is due, in part, to the relative newness and rate of growth of the motorcycle population. Lightweight motorcycles were first introduced into the United States in the early 1960's. Since then, motorcycle registrations have been doubling every four to five years (with some recent flattening of this trend).

The initial geographic area of widespread acceptance was in California and other West Coast states. For this reason, the early legislation in terms of motorcycle noise regulations was promulgated by the State of California. In response to this legislation, which establishes maximum allowable noise levels of motorcycles sold in California, noise levels of new motorcycles have been changing significantly. For example, typical maximum A-weighted sound levels at 50 feet (15.2 m) have been reduced from approximately 93-106 dB in 1971 to approximately 71-88 dB in 1974.

The continuing pressure from existing and/or future legislation for lower noise levels will force a continuing state of change. This places a great burden on the measurement methodology development in that it requires the procedure to be such that it provides data which will be meaningful in the implementation and evaluation of noise control measures in addition to determining compliance with a regulated level.

2. Motorcycle Description and Design

2.1. Definition

The Task Force on Noise to the State of Illinois, Institute for Environmental Quality[1][1/] defined a motorcycle as "every motor vehicle having a seat or saddle for the use of the rider and designed to travel with not more than 3 wheels in contact with the ground, but excluding a tractor." A somewhat modified definition was given by the Society of Automotive Engineers (SAE) Recommended Practice J213a[2] - Definitions-Motorcycles. They defined a motorcycle as "any two wheeled vehicle with a propelling engine having a piston displacement ranging from less than 50 cubic centimeters to more than 170 cubic centimeters and weighing less than 1000 pounds curb weight (the total weight of a vehicle, including a full load of fuel, oil, and water but without any passengers or cargo) or any three-wheeled vehicle with a propelling engine and weighing less than 1500 pounds curb weight." This definition includes only those vehicles which are intended at least partially for public road use and excludes vehicles which do not meet common legal requirements for public road use. However, the most comprehensive description of a motorcycle was given in a report entitled "Control of Motorcycle Noise, Volume I, Technology and Cost Information"[3], prepared by Wyle Laboratories, which stated: "with few exceptions, the motorcycle is a two wheeled vehicle powered by a carbureted, spark ignition, air cooled, reciprocating, two or four stroke engine driving through a manual clutch and multi-ratio gearset."

[1/] Numbers in brackets indicate literature references at the end of this report.

It should be noted that in addition to motorcycles, there are also vehicles termed "motor driven cycles." These vehicles are normally treated separately from other vehicles in state and municipal vehicle codes. For example, the state of California classifies separately those vehicles with a horse power rating of 15 hp or less and an engine displacement of 200 cc or less as being a motor driven cycle. However, for the purpose of this report, when the term motorcycle is used, motor driven cycle is implied.

2.2. Industry Structure

The motorcycle industry is comprised primarily of foreign manufacturers. Eighty-eight percent of the motorcycles sold in the United States are manufactured in Japan, shipped to Japanese-owned distributors in the United States, retailed by independent dealers who typically carry only a single manufacturer's line, and subsequently equipped and serviced with parts or accessories made by U. S. suppliers. European manufacturers supply about 5 percent of the market. The largest U. S. Motorcycle manufacturer is AMF/Harley-Davidson which provides about 5 percent of the U. S. unit sales. Since both European and American firms sell smaller numbers of motorcycles, they either market through distributors or sell directly to franchise dealers. The market is concentrated, in the sense that six manufacturers supply approximately 95 percent of American unit sales. See Table 1 for a listing of principal suppliers of motorcycles to the United States.

2.3. Design Characteristics and Product Classification

Design characteristics and product classification are important interactive parameters for noise regulation in that these factors may differentially influence noise output and usage in a manner that would require accommodation in order to produce fair and equitable measurement methodology and/or regulation. In the case of automobiles, for example, experience in California has clearly indicated that a maximum noise regulation does not imply uniformly controlled noise in typical use.

Four different classes of motorcycles can be readily identified according to their end use, including:

1. Highway motorcycles

2. Off road motorcycles

3. Dual-purpose motorcycles

4. Mini bikes.

Further classification of highway and dual-purpose motorcycles can be made according to engine displacement, or horsepower, according to their legally permitted use. California, for example does not permit motorcycles of less than 15 horsepower (motor driven cycles) to use certain high speed, limited

Table 1

Percent of Market Share by Motorcycle

Manufacturers in the U. S. Market as of 1973[3]

Manufacturer	Percent of Units Sold in United States	Location
Honda Motor Company	48.6	Japan
Yamaha Motor Co., Ltd.	18.9	Japan
Suzuki Motor Corporation	12.2	Japan
Kawasaki Motors Corporation	8.2	Japan
AMF/Harley-Davidson Motor Co., Inc.	4.6	U. S. A.
The Birmingham Small Arms Co. Ltd. (BSA, Triumph)	3.2	England
Bavarian Motor Works	0.6	Germany
Bultaco Motors	0.6	Spain
Hodaka Industrial Co., Ltd	0.4	Japan
OSSA	0.4	Spain
Husquarna	0.3	Czechoslovakia
Benelli	0.2	Italy
	98.2%	

access highways. This limitation may be translated into engine displacement, since with current state-of-the-art of production motorcycles, this implies an engine of 150-200 cc. displacement.

For the purposes of further discussion, the four major classifications will be identified as follows (from reference [3])

- Highway motorcycles are produced in the entire size and performance range and are standard transportation models produced for licensing and use on public highways. They contain all required safety equipment (lights, horn, passenger seat and handhold, turn signals, etc.,) and have the least critical weight and size requirements.

- Dual purpose motorcycles are a design compromise including features which allow reasonable operation both on the highway and in nonpaved or natural areas. Differences from pure highway machines include generally smaller components for less weight, increased ground clearance usually requiring a high mounted and smaller exhaust, changes in frame geometry, suspension, engine output characteristics, and occasionally different tire size and tread type.

- Off road motorcycles are designed for use over natural terrain only, and contain no features oriented toward highway use. Performance demands for off road use, which often includes racing and other competitive events, require extreme light weight, balance and agility. Thus, items such as seat, fuel tank, fenders, intake, and exhaust systems are of minimal functional dimensions. Dual purpose and off road motorcycles are available in engine displacements of 500 cc or less.

- Minibikes exist in many forms, from accurately scaled down motorcycles to simple tube frames on small tires powered by lawn mower type engines. Intended for general off road use by children, some high developed minibikes produced by large manufacturers also contain the equipment necessary for highway licensing.

Table 2 shows the range of design parameters of currently (1974 model) manufactured highway motorcycles[3]. Of particular interest is the relatively low machine weight (compared to transported weight) and the large range in power (reflected in the wide range of power to weight ratio).

In view of the different purposes of the products as sold, different end uses, and widely different sizes, it would appear that equitable regulation would require different operational procedures for the different classes of motorcycles -- unless data are available, or can be generated, that indicate that all classes generate a given noise condition, e.g., maximum noise, under the same operating conditions.

Table 2

Manufacturer Specification Ranges for Standard Highway Motorcycles and Motor-Driven Cycles[3]

Displacement, cc	50 to 1200
Maximum Power, hp	4.9 to 82
Maximum Engine Speed, rpm	5900 to 10,000
Specific Power Output, hp/100 cc	4.5 to 12.7
Weight, lb	143 to 722
Power to Weight Ratio, hp/lb	0.039 to .17
Wheelbase, in	43.3 to 61.5
Number of Gear Ratios	3 to 10
Top speed, mph	50 to 130
Fuel Consumption, mpg	20 to 90

3. Effects of Noise and Parties Affected

Motorcycles are used in a wider range of places for a wider range of purposes -- e.g., basic transportation, recreation, off-highway, etc. -- than any other type of motor vehicle; therefore, the noise produced by these devices can affect the community in a wide range of ways. One study[4] has noted that motorcycles are second only to automobiles (out of all motor vehicle sources) in terms of the number of annoying situations created, and they were found to produce more intensely annoying situations than all other vehicular sources except buses. Since the time of that report, there has been some progress in motorcycle noise control resulting from enforcement of regulations at the state and local level which may reduce the intensity of annoyance; however, it should also be noted that nationwide motorcycle registrations have increased by approximately 80 percent during that period, which probably resulted in a corresponding increase in the extensity of annoyance. For example, use of off road vehicles in park lands has created such a noise problem that the USDA, Forest Service has proposed noise limits[5] for motorcycles operated on National Forest Lands. Estimates of the "vanishing distance" (distance to inaudibility) for 1973 and 1974 off highway motorcycles in the 125-250 cc displacement range was estimated to be 1400-3900 feet (427-1189 m)[6].

Assuming a mean "vanishing distance" of about 2500 ft. (762 m) (and ignoring terrain effects), this implies that with a density of 4-5 motorcycles per square mile of parkland, visitors to the nation's parklands are never (on the average) out of earshot of a motorcycle. These examples are cited to indicate that the potential for annoyance from motorcycle noise is widespread. As noted in several reports, the annoyance response arises from the many possible interferences due to noise with everyday activities ranging from interruption with sleep or listening activities[4,7] to simply the information carried implying that a motorcycle is present where its use may be inappropriate[8].

In addition to annoyance and task interference, the motorcycle may represent a potential source of hearing damage in the exposed out-of-doors community, and certainly represents a strong potential source for hearing damage to the operator. Maximum A-weighted sound levels at 25 ft (7.6 m) can exceed 90 dB, while mean A-weighted sound levels at the operator's ear -- at least for trail riding -- are in the range of 85-98 dB. The motorcycle is unique among highway transportation noise sources with respect to potential operator hearing damage, and the regulation and/or measurement methodology should address this problem.

4. Major Noise Sources

Because of possible impact on the test procedure, it is useful to identify the major sources of noise in motorcycles and the effect of normal operation on the noise levels associated with each of these sources. Basically the sources are as follows:

Exhaust Noise - is created when high pressure exhaust gases, released through the engine exhaust valves or parts, excite oscillations in the exhaust system which are radiated to the atmosphere at the tail pipe, through the pipe surfaces and through the muffler shell at an amplitude determined by the system configuration. The noise is a function of engine type, timing, load and speed (rpm), intake system type, muffler type and size, pipe diameter, pipe bends, dual or single system, etc.

Air-Intake Noise - is created by the opening and closing of the intake valve which causes the volume of air in the intake system to pulsate. Associated noise levels are dependent upon whether the engine is 2-cycle or 4-cycle, load and speed (rpm), the number of cylinders, the engine displacement, etc.

Engine (Mechanical) Noise - is primarily produced by the combustion process which produces rapid changes in pressure in the cylinder which in turn results in excited mechanical impact and vibration in the engine structure. Some of this vibrational energy is subsequently radiated to the atmosphere as acoustic energy.

Transmission and Drive Noise - arises from the meshing and movements of gears and bearings within the gear ratio assembly and may be apparent under load or no load conditions. The noise may be aggravated by resonance of the gearbox casing or by structure-borne components that excite body surfaces that act as efficient radiators. Most motorcycles employ a chain drive for conveying power from the gearbox to the driven wheel. The attendant noise is a function of the type and state of chain lubrication, chain loading, and speed of chain motion.

Tire-Road Interaction Noise - is related to tire and tread configuration, road surface texture, vehicle speed, load, and state of tire wear. Vibration of the tire carcass and the entrapment and release of air from tread/pavement interstices appear to be the major mechanisms for tire noise generation.

Aerodynamic Noise - is created by turbulent passage of air in and around the motorcycle components and rider. The magnitude of aerodynamic noise depends primarily on vehicle speed, vehicle aerodynamics, and wind velocity.

Noise from Accessories - is created by vibration of fenders, fuel tank and side panels due to the various engine, drive, and road excitations.

Appendix A contains a more detailed discussion of the component noise sources.

5. Modes of Operation for Motorcycles

The current literature provides very little information on the manner in which motorcycles are typically used. However, there is some information, in the form of a social survey[4], on motorcycle use patterns which cause annoyance. Survey results indicate that 68% of the respondents who indicated that motorcycles were annoying suggested that the annoying vehicle was accelerating (as opposed to steady speed (17%), decelerating (0%), or not relevant (13%)). This may be interpreted as a loudness judgment, however, since an acceleration usually does create higher noise levels.

The only bounds that can be placed on modes of operation at this time are the physical and legal limitations of operation. Thus, cruise speed will be typically limited by aerodynamic drag and horsepower, to the extent that many low power highway and dual purpose machines are incapable of speeds in excess of 65 mph under optimum conditions and are in fact designed to cruise at speeds at or below 45 mph. Larger highway machines are easily capable of maintaining posted speed limits on any road surface. Minibikes are typically smaller than off highway machines and face similar off highway terrain limitations so that operating speeds are more frequently in the range of 10-25 mph.

6. Existing Measurement Procedures

In this section, the existing measurement procedures, relevant to determination of the noise emission from motorcycles, are presented and compared. In addition, the feasibility of an operator-at-ear noise level measurement procedure is discussed.

6.1. Environmental Noise

There are six existing measurement procedures which may be applicable to the measurement of the environmental impact noise level produced by motorcycles. They are:

(1) Society of Automotive Engineers (SAE) Standard J331a -- Sound Levels for Motorcycles[9],

(2) California Highway Patrol (CHP) Noise Measurement Procedure[10],

(3) Society of Automotive Engineers (SAE) Standard J47 -- Maximum Sound Level Potential for Motorcycles[11],

(4) International Organization for Standardization (ISO) Recommendation R362 -- Measurement of Noise Emitted by Vehicles[12],

(5) ASA STD 3-1975 -- Test-Site Measurement of Maximum Noise Emitted by Engine-Powered Equipment[13], and

(6) U. S. Forest Service Proposal -- Sound Level Standard and Test Procedure for Motorcycles[5].

To better facilitate a discussion of these measurement procedures a table -- Table 3 -- has been prepared which outlines the pertinent sections of each of the test methods. This table permits rapid comparison among the six procedures. With the exception of ASA STD 3-1975 (permission to reprint this standard was not granted by ASA), complete texts of the finalized measurement procedures are reproduced in Appendix B.

The SAE J331a and CHP procedures are presently the most widely used standards in the United States for establishing motorcycle noise levels for legal compliance. Practically all reported noise level data are based on these two procedures[17]. The SAE standard was designed to measure maximum noise produced by motorcycles under typical highway operation without considering the influence of tire noise. The noise level produced during such a test is intended to represent the worst case noise level for motorcycles operating under urban driving conditions. This standard is intended as a design tool and, as such, the standard recommends that a maximum A-weighted sound level of 82, 84 or 86 dB dependent on the vehicle engine displacement (169 cm^3 or

Table 3. Comparison of existing and proposed measurement procedures for determining the noise impact of motorcycles.

Measurement Procedures	SAE J331a	CHP	SAE J47	ISO R362	ASA STD 3-1975	U.S.F.S. Proposal
Vehicles covered by procedures	Motorcycles	All motor vehicles	Motorcycles	All motor vehicles	Motor vehicles, public conveyances, construction and industrial machinery residential and recreational vehicles powered by engines operating on petroleum-based fuels, coal, steam, electricity, or other source of energy.	Motorcycles
Instrumentation	1. Type 1 sound level meter meeting the requirements of ANSI S1.4-1971.[2] 2. Alternative measurement system meeting the requirements of SAE J184.[3]	Type 1, 2 or S2A sound level meter meeting the requirements of ANSI S1.4-1971.	1. Type 1 sound level meter meeting the requirements of ANSI S1.4-1971. 2. Alternative measurement system meeting the requirements of SAE J184.	Sound level meter meeting the requirements of IEC Recommendation 123.[4]	Sound level meter meeting the requirements of ANSI S1.4-1971. Type 1 for certification, type 2 for enforcement or survey.	1. Sound level meter meeting the requirements of ANSI S1.4-1971. 2. Alternative measurement system meeting the requirements of SAE J184.
Test Site	Flat open space free of large sound reflecting surfaces within 100 ft (30m) radius of the microphone location and a point 50 ft (15 m) before or 50 ft (15 m) beyond the microphone point on the vehicle path.	Flat open space free of reflecting surfaces located within 100 ft (30m) of either the vehicle path or the microphone.	Flat open space free of large sound reflecting surfaces within 100 ft (30m) radius of the microphone location and a point 50 ft (15 m) before or 50 ft (15 m) beyond the microphone point on the vehicle path.	Level, open space of some 164 ft (50m) radius free of reflecting surfaces within a radius of 82 ft (25m) from the vehicle.	Open space of uniform grade not exceeding 2 percent on the average in any direction, and free of reflecting surfaces within 100 ft (30m) of either the equipment under test or the microphone.	Flat open space free of large reflecting surfaces within 50 ft (15 m) of either the vehicle or the microphone.
Measurement Area Surface	Concrete or asphalt.	Concrete or asphalt.	Concrete or asphalt.	Concrete, asphalt or similar hard material.	Concrete, asphalt or similar hard material[5]	Paved surface.
Vehicle Path Surface	Concrete or asphalt.	Concrete or asphalt.	Concrete or asphalt.	Concrete, asphalt or similar hard material.	Concrete or asphalt.	Paved surface or well-packed earth or gravel.
Length of Vehicle Path	150 ft (45 m)	200 ft (60 m)	100 ft (30 m)	66 ft (20 m)	100 ft (30 m)	50 ft (15 m)
End Zone	Last 75 ft (22.5 m)	Last 100 ft (30 m)	No real end zone.	No real end zone.	No real end zone.	No real end zone.
Acceleration Point	25 ft (7.5 m) prior to microphone.	25 ft (7.5 m) prior to microphone.	A minimum of 25 ft (7.5 m) prior[6] to microphone.	33 ft (10 m) prior to microphone.	50 ft (15 m) prior to microphone.	25 ft (7.5 m) prior to microphone.
Microphone Location	50 ft (15 m) from the centerline of the vehicle path and 4 ft (1.2 m)	50 ± 1 ft from the centerline of vehicle path and 4 ± 1/2 ft above the	50 ft (15 m) from the centerline of the vehicle path and 4 ft (1.2 m)	25 ft (7.5 m) from the centerline of the vehicle path and 4 ft (1.2 m)	50 ft (15 m) from the centerline of the vehicle path and 4 ft (1.2 m)	50 ft (15 m) from the centerline of the vehicle path and 4 ft (1.2 m)

Table 3 (continued)

Measurement Procedures	SAE J331a	CHP	SAE J47	ISO R362	ASA STD 3-1975	U.S.F.S. Proposal
	above the ground plane.	plane of the road-way surface.	above the ground plane.	above the ground level.	above the ground plane.	above the ground plane.
Vehicle Operation	Wide open throttle acceleration, closed throttle deceleration.	Wide open throttle acceleration, closed throttle deceleration.	Wide open throttle acceleration, closed throttle deceleration.	Wide open throttle acceleration, stationary runup, constant speed passby.	Wide open throttle acceleration, closed throttle deceleration.	Wide open throttle acceleration.
Vehicle Reference Point	Front of vehicle.	Front of vehicle.	Front of vehicle.	Not specified 7/	Front of vehicle.	Front of vehicle.
Quantity Measured	Maximum A-weighted sound level, fast response.	Maximum A-weighted sound level, fast response.	Maximum A-weighted sound level, fast response. 8/	Maximum A-weighted sound level, fast response.	Maximum A-weighted sound level, fast response.	Maximum A-weighted sound level, fast response.
Reported Value	Average of four readings within 2 dB of each other for the noisiest side of the vehicle; at least six measurements are required where the highest and the lowest readings are discarded	Average of two highest readings within 2 dB of each other for the noisiest side of the vehicle, four measurements required for each side.	Average of four readings within 2 dB of each other for the noisiest side of the vehicle; at least six measurements are required where the highest and the lowest readings are discarded.	Two measurements required each side, all values reported.	The maximum sound level (for a minimum of three readings that are within 2 dB of each other, for the noisiest side of the vehicle	Average of two highest readings within 2 dB of each other for the noisiest side of the vehicle; at least two measurements required for each side.

2/ American Standard Specifications for Sound Level Meters, S1.4-1971, American National Standards Institute, New York, New York (1971)[14].

3/ SAE Recommended Practice J184, Qualifying a Sound Data Acquisition System, Society of Automotive Engineers, Pittsburg, Pennsylvania (1970)[15].

4/ International Electrotechnical Commission Recommendations for Sound Level Meters, Publication 123[16].

5/ The ground surface between the microphone and the equipment under test shall be flat concrete, asphalt, or similar hard material, unless the equipment is intended for use on rail, water or snow.

6/ The acceleration point is established as the shortest distance (minimum of 25 ft (7.5 m)) prior to the microphone that is required for a vehicle to reach its maximum rated horsepower at a distance of 25 ft (7.5 m) beyond the microphone.

7/ Specific reference point is not stated in the measurement procedure, however, the front of the vehicle is implied.

8/ The maximum A-weighted sound level is obtained using the lowest operating gear (1st gear).

less, 170 through 500 cm^3 or more than 500 cm^3 respectively), when measured in accordance with J331a procedures, be used as a reference in the design and development of motorcycles. In addition a 2 dB allowance is recommended for variations in test site temperature gradients, test equipment, and inherent differences in nominally identical vehicles[9,17].

The CHP procedure (implementing Section 27160 of the California Vehicle Code which applies to the measurement of noise from new motor vehicles, including motorcycles, offered for sale in the state of California) is very similar to the SAE J331a procedure. However, since the vehicles covered by the CHP test include passenger cars and light trucks, medium and heavy trucks and buses, in addition to motorcycles, the specification of the test site geometry in the CHP procedure differs from that specified in SAE J331a. The CHP test site is basically a compromise combination of the test sites specified in SAE J986a (passenger cars and light trucks), SAE J366b (heavy trucks and buses) and SAE J331a (motorcycles). Another difference occurs in the instrumentation requirements. The CHP allows the use of type 2 of S2A instrumentation in lieu of Type 1 (precision) equipment for enforcement purposes.

A second SAE measurement procedure -- SAE J47 -- was developed in addition to SAE J331a. It is intended primarily to be a manufacturing tool for determination of the maximum sound level potential for motorcycles (without considering the influence of tires), and was in no way intended to represent the way a motorcycle is driven on the public highways or in urban areas[17]. This test procedure is considered by many to be unsafe, and even dangerous, since it requires a test vehicle to operate in its lowest gear (first gear) under maximum acceleration, resulting in front wheel lift off on most machines. Such operation requires a skilled operator to maintain some margin of control over the vehicle. Since this test requires vehicles to accelerate more rapidly than normal, the specification of the test site geometry differs from that specified in the SAE J331a and CHP procedures. The SAE J47 test site specifications require that the maximum rated engine speed be reached just beyond the microphone point on the vehicle path (a minimum distance of 25 ft (7.5 m)). The instrumentation and recommended 2 dB allowance for uncontrollable conditions is identical to that specified by the SAE J331a procedure.

ISO R362 is the applicable international standard for the measurement of exterior motor vehicle noise, including motorcycles. The use of this standard is especially widespread in Europe. As was the case with the CHP procedure, this standard covers all vehicles and allows the use of essentially type 2 instrumentation. However, the test site geometry is very similar to the SAE J47 site specification. The major difference, which is a common one between domestic and international standards, is the fact that measurements are made at 7.5 m (25 ft.) instead of 15.2 m (50 ft.).

The ASA standard specifies methods for determining the maximum noise emitted by a variety of engine powered equipment, including motorcycles. The procedures stipulated are intended as a tool for certification testing by manufacturers, conformance testing by community agencies, and survey testing for community noise intrusion. As was the case with the CHP and ISO R362 procedures, the standard covers all motor vehicles; however, the test site geometry is similar to that specified in the SAE J47 and ISO R362. In addition, the instrumentation requirements are identical to those specified in the CHP procedure, with the exception that type 1 (precision) equipment is required for certification tests while type 2 equipment is allowed for survey or enforcement purposes.

It should also be noted that the ASA standard specifies, in addition to a passby test procedure, a stationary test procedure. However, the stationary test methods only apply to construction, industrial and residential equipment, highway and off-highway equipment having auxiliary powered equipment, and auxiliary equipment separately.

The United States Forest Service (USFS) Proposal establishes measurement methodologies and describes sound level limits for motorcycles used on National Forest lands. This standard is designed to extract the maximum noise produced by motorcycles under typical off-road operations, without considering the influence of tire noise. It is also intended as a design tool and as such the standard recommends the following maximum A-weighted sound levels -- when measured in accordance with U.S.F.S. Proposal procedures -- be used as a reference in the design and development of motorcycles operated on National Forest lands:

(1) All presently constructed motorcycles -- not to exceed a maximum sound level of 86 dB,

(2) All new motorcycles sold after January 1, 1975 -- not to exceed a maximum sound level of 82 dB, and

(3) All new motorcycles sold after January 1, 1980 -- not to exceed a maximum sound level of 75 dB.

In addition a 3 dB allowance is recommended (instead of the 2 dB allowance recommended by the SAE procedures) for variations in test site, vehicle operation, temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles. However, the test site geometry is very similar to the SAE J47 and ISO R362 site specifications, while the instrumentation specifications are identical to those required by SAE J331a.

There is one other test procedure that should be discussed due to its simplicity of application. It is not listed in Table 3 due to the lack of necessary data required for a fair comparison of this test procedure to the other six test procedures. The test procedure referred to is the Federal International Motorcyclist (FIM) Recommended Noise Testing Method designed exclusively for measuring the noise emission from racing bikes (motorcycles). This method employs a very simplified test procedure which consists of utilizing a sound level meter located 50 ft. (15.2 m) directly behind the vehicle while it operates at some pre-determined engine speed (at a stationary position) in order to obtain the A-weighted sound level of the vehicle. A maximum A-weighted sound level of 92 dB is recommended for all vehicles. See

Appendix B for the entire text of this test procedure.

It should also be noted that there are additional motorcycle measurement procedures in the various stages of development. For example, the Motorcycle Industry Council (MIC) has recently proposed a measurement procedure that is intended strictly for racing and competition machines.

All of the procedures discussed above measure the same acoustic quantity; namely, the maximum A-weighted sound level with fast meter response. Also each of the procedures utilize the wide open throttle acceleration mode of operation as the primary test although procedures for closed throttle deceleration (SAE J331a/CHP/SAE J47/ASA) and stationary acceleration (ISO R362) tests are also outlined. However, there is one crucial factor that may affect the acceleration mode of the vehicle -- that is the test weight specifications as outlined by the SAE J331a procedure. Since weight is a critical element in smaller vehicles' ability to accelerate, the SAE J331a procedure recommends that the driver's weight be not less than 165 lbs (74.8 kg) and not more than 175 lbs (79.4 kg). This weight requirement includes all necessary test equipment which might be attached to the vehicle[9,17].

Currently within ISO, a revision of R362 is being considered. Review of a recent draft points out only two significant differences between the original and revised standard -- (1) the revised standard requires the use of precision instrumentation meeting the requirements of IEC Publication 179 and (2) the provisions for a stationary acceleration test and a constant speed passby test have been deleted. In addition to the revision to ISO R362, a second document is being developed which outlines a survey method for measurement of noise emitted by stationary motor vehicles. This document provides specifications for instrumentation, test site, microphone locations and vehicle operating conditions as part of a procedure for making near-field measurements of exhaust and engine noise.

As stated earlier in this section, the FIM test procedure is a simplified procedure that utilizes a stationary acceleration (or "run-up") test method for determining the noise output of motorcycles. This test method deserves further evaluation, especially since such a test is also prescribed in the Federal Interstate motor carrier noise emission standards pertaining to trucks. In the Federal Standard this test specifies that the vehicle should be accelerated at wide-open throttle to its governed engine speed as rapidly as possible while the vehicle is stationary with its transmission in neutral. One problem with this test procedure is that its application is limited to vehicles with governed engines.

6.2. Operator At-Ear Noise

There are no standardized measurement procedures directly applicable to the measurement of noise produced at the ear of the motorcycle operator; and, as a consequence, there is practically a non-existent data base available in the public domain on the noise levels normally "heard" by the operator. Unlike most vehicle operators, the motorcyclist is constantly exposed to unobstructed noise levels by virtue of his unshielded condition during vehicle operations. The noise level produced at the operator's position (ear level) can be highly annoying as well as pose a serious threat of possible hearing loss or damage as a result of prolonged exposure. The sound levels generated are generally dependent on two factors[9/], (1) vehicle type and operational procedure, and (2) vehicle speed. Although most motorcycle operators normally wear protective helmets, these devices are considered to have only a nominal effect on noise reduction at the ear of the operator depending on the style, fit and type of eye protection afforded by the helmet and the speed of the vehicle[18].

Not until recently, however, have any efforts been made to develop a test procedure which could be used to evaluate the potential for hearing damage of motorcycle operators. In reports entitled "Motorcycle Noise" and "Operator's At-Ear Noise Exposure for Off-Road Recreational Vehicles", by Robin Harrison, U. S. Department of Agriculture, Forest Service[8,19], a test procedure was devised to measure the noise level produced at the operator's ear -- in order to assess the noise level present at this position that may cause possible hearing damage. To better facilitate a discussion of this test procedure Table 4 has been developed which outlines the pertinent areas of the test method.

Drivers utilized several motorcycles typically designed for off-road purposes (i.e., dual purpose or competitive type vehicles) to evaluate this test procedure. These vehicles were tested at three different sites which were consistent with normal motorcycle operation -- i.e., 1) an area that consisted of rough terrain and steep hills which required low speed operation to negotiate, 2) an area that consisted of a large, open, flat smooth surface that was conducive to high speed operation, and 3) an area that was somewhat restricted in nature that required average or moderate speeds to negotiate. See Table 5 for a description of each motorcycle used and the type of test site utilized.

The riders of these vehicles were fitted with a helmet-mounted microphone which was coupled to a tape recorder that was carried by the operator in a backpack. The sound levels recorded at the operator's ear were analyzed in terms of two parameters -- (1) A-weighted sound level distribution with time (to determine the time distribution of at-ear intensities), and (2) spectral content (to determine the frequency of the noise signal at the time of occurrence of the maximum A-weighted level experienced during normal operation at the operator's ear). The instrumentation used in the data gathering and analysis process is given in Figures 1 and 2.

9/ Vehicle type and operational procedures are the determinant factors of operator-at-ear noise levels for motorcycles traveling under 40 mph. An A-weighted sound level of 100 dB has been reported at the operator's ear for motorcycles traveling at 20 mph (32 km/hr). At speeds greater than 40 mph (64 km/hr), operator-at-ear noise levels are considered to be strictly a function of vehicle speed alone and completely determined by aerodynamic noises (although a narrow portion of the frequency range radiated by the components of the motorcycle may also be heard by the operator) -- an A-weighted sound level of 110 dB has been reported at the operator's ear for motorcycles traveling at 70 mph (112 km/hr)[3].

Table 4

Operator-at-ear Noise Test Procedure

Type of Vehicles Used	Off-road Motorcycles
Instrumentation	(1) B & K Microphone, type 4117[10/] (2) Kudelski Nagra III tape recorder (3) B & K Spectrum Shaper (4) B & K 166 environmental noise monitor (5) Hewlet-Packard real-time 1/3 octave band analyzer (6) PDP-8 Computer
Test Site	(1) Rough ground and steep hills (2) Vast open expanse of smooth, flat, hard lake bed (3) Forest trail
Microphone Location	Adjacent to operator's ear inside of helmet
Vehicle Operation	(1) Low speed operation (2) Full-throttle accelerations (3) Moderate speed operation
Quantity Measured	(1) A-weighted level distribution in time (2) Maximum A-weighted noise spectra

[10/] Commercial instruments are identified in this report to adequately specify the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the equipment identified is necessarily the best available for the purpose.

However, these data represent only a first attempt to establish an appropriate measurement procedure for at-ear operator noise. Thus, it appears that EPA should generate an extensive physical data base that can serve as the basis for development of an at-ear measurement methodology, prior to the formulation of the Notice of Proposed Rule Making.

7. Data Base and Correlation

Motorcycle noise data exist in limited quantity in the public domain. Since 1969, the application of noise control technology to motorcycles has been necessitated by the enactment and enforcement of noise emission regulations by various state and municipal governments. These regulations for the most part have adopted existing motorcycle measurement procedures. The regulations in general apply to new and older motorcycles; thus, industry has been evaluating alternative approaches to noise control for the last five or six years in order to ensure that their products are in compliance with the regulations.

Although there is probably some proprietary data which has been obtained by the motorcycle industry and data resulting from state and local compliance testing[11/], it appears doubtful that the existing data is sufficiently extensive to provide EPA with even a nominal fraction of the information needed for a comprehensive analysis of the economic costs and technical feasibility associated with a given regulation. Furthermore, it is evident that there is very little data upon which to base an evaluation of alternative motorcycle noise measurement procedures or to establish correlations between the noise associated with various operational modes and the noise measured according to the various test procedures.

Thus it appears that EPA will have to generate a rather extensive physical data base and investigate alternative measurement procedures prior to formulation of the Notice of Proposed Rule Making.

8. Overview of Motorcycle Noise Measurement Difficulties

The information discussed in Sections 2 through 7 of this report serves as the basis for an overview of motorcycle noise measurement problems. Utilizing this information, potential noise measurement problems that could hinder the promulgation and/or enforcement of future noise regulations to control noise emission from motorcycles are identified.

Prior to the establishment of an appropriate measurement procedure that can be utilized for determining the environmental impact and at-ear noise level of motorcycles, certain informational requirements must be satisfied. These include: (1) a product classification scheme, (2) typical usage data (normal use conditions and range) and the effects of operation and environment on generated noise levels, and (3) the effects of motorcycle noise on

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11/ Due to the disparities among state and local jurisdictions in implementing standardized noise measurement techniques the resultant data may be difficult to compare.

Table 5

Test Motorcycles and Site Location

Year	Engine Displacement	Type	Classification
Motorcycles used over Rough Terrain, Steep Hills and Open Flat Smooth Surfaces			
Early			
1973	250 cc	2-stroke	Dual purpose
1973	100 cc	2 stroke	Dual purpose
1973	125 cc	2 stroke	Dual purpose, Proto-type
1973	250 cc	4 stroke	Dual purpose
1973	500 cc	4 stroke	Dual purpose
1973	250 cc	2 stroke	Professional racer
Motorcycles Used Over Forest Trails			
Late			
1973	250 cc	2 stroke	Dual purpose
1974	250 cc	2 stroke	Dual purpose
1974	125 cc	2 stroke	Dual purpose
1974	125 cc	4 stroke	Trials competition motorcycle

people, including the operator, and the nature of the effects. Such data allows one to select, with confidence, the acoustic quantity to be measured, the operational mode(s) of the vehicle during measurement and the appropriate acoustic measurement procedure(s) which need to be specified in the regulation. Test site and operational limitations, and instrumentation requirements also hinge on the availability of this fundamental information.

It must be borne in mind throughout the following discussions that the motorcycle as a noise source is a rapidly changing subject, and for this reason, any data with respect to the problems raised, must be reviewed for

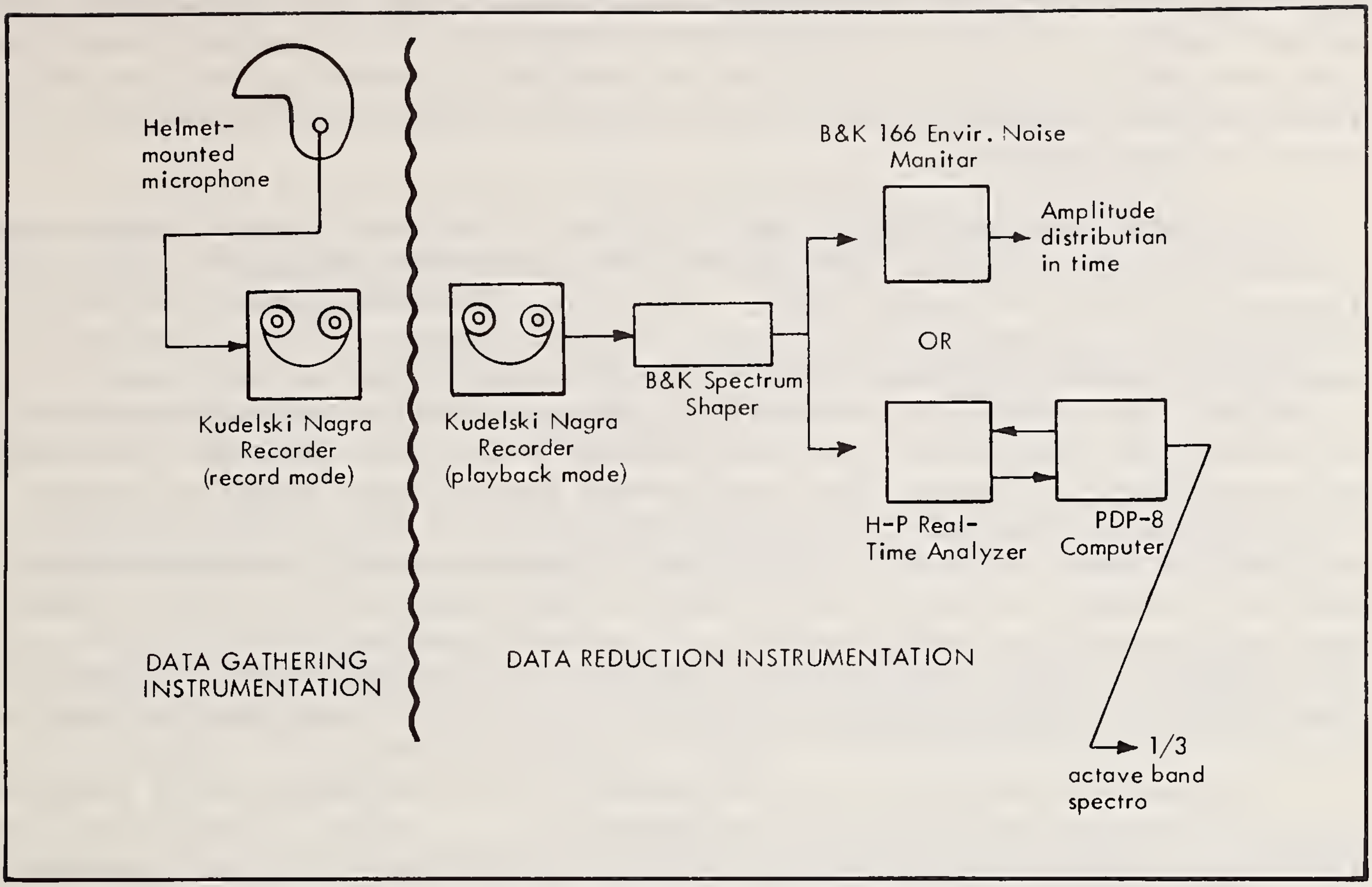

Figure 1. Operator at-ear noise measuring instrument system (schematic).

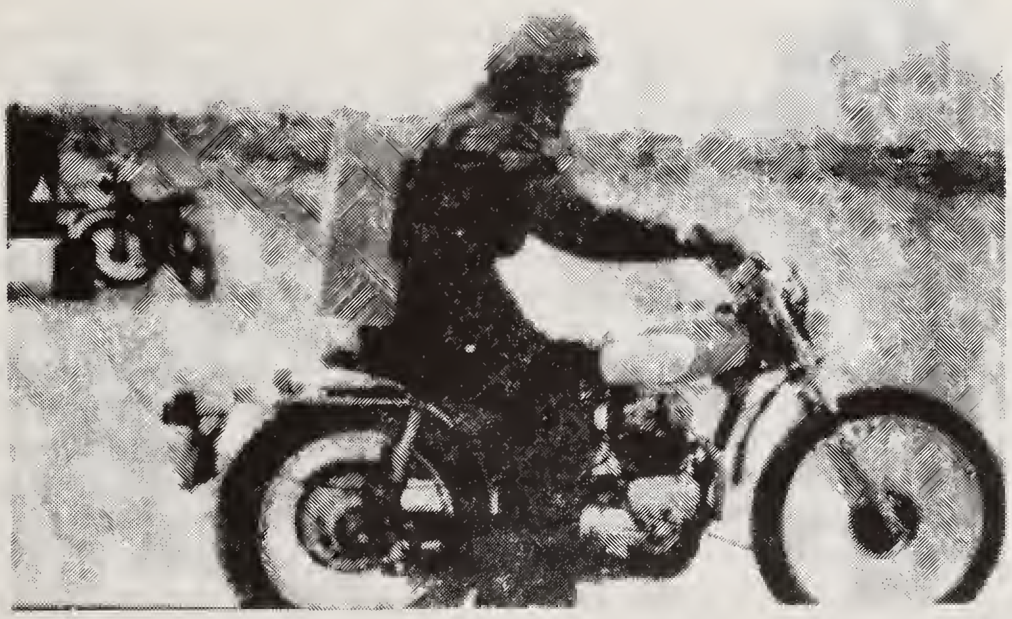

Figure 2. Helmet-mounted microphone and backpack tape recorder.

their currency. As has been noted, the pressure from state and local legislation has significantly altered the acoustic output of the typical motorcycle as sold today. At this juncture, it is reasonable to treat data on physical characteristics of motorcycle noise as obsolete if taken on vehicles manufactured prior to 1973, and old (with possibly questionable applicability) if more than one year old.

The fact that the bulk of motorcycles are imported creates some unique problems for selection of appropriate measurement methodologies, due to the interaction with the group likely to perform the measurements. It can be expected that an assembly plant or a distributorship will not have readily available, the engineering staff required to supervise and maintain an extensive or sophisticated acoustic measurement program, even though such expertise may be expected at the design and manufacturing site. On the other hand, it is also reasonable to expect that the foreign manufacturer might not permit the verification of data at his foreign test site that recent proposed source regulations have required of the domestic manufacturer. Successful regulation will require recognition of these unique nonacoustic problems. Since it may be expected that such testing will be performed in the U. S., the attendant requirements of the regulation for skilled test personnel -- in light of the limited pool of such personnel presently available -- must also be considered.

Another unique factor in this industry is the existance of a large after market accessory industry which is primarily U. S. based. Since this industry produces a significant number of components which may alter the mechanical and/or acoustic performance of the product, this regulation should identify labeling requirements and measurement techniques which would ensure maintenance of new product noise levels consistent with community needs.

8.1. Classification

Some of the factors associated with the establishment of motorcycle classes have been discussed in Section 2. There are actually two major purposes for motorcycle classification in conjunction with noise regulations.

1. In order to establish different measurement procedures, or variations of the same measurement procedure, for motorcycles which have different operational characteristics or which exhibit important variations in their acoustical characteristics.

2. In order to set different noise limits on different categories of motorcycles, either because they are used differently and thus affect people in different ways, or because of economic cost and technological feasibility of noise control as applied to the various classes of motorcycles.

Although motorcycle noise data is relatively abundant compared to other vehicular noise sources, sufficient data to allow adequate correlation between the classes of motorcycles -- categorized by engine displacement, weight and size, intended usage, etc. -- and the resultant noise levels characteristic of each class over the range of normal operation (as opposed to maximum acceleration) does not exist in any meaningful quantity.

8.2. Relation of Physical Measures to Effects/Normal Use

It is likely that the test procedure established for motorcycle environmental impact and operator at-ear noise measurements should be such that the measured noise levels are representative of typical operation and not necessarily maximum levels.

At least three types of measurements come to mind when one considers measurement procedures which will permit adequate assessment of the noise exposures of the several groups affected:

Sideline "far-field" noise, representative of the noise which is radiated to listeners located back from the side of a road, trail or highway in a rather open and/or wooded area.

Sideline "near-field" noise, representative of that which is heard by passing pedestrians and motorists and by those working or living, or utilizing recreational facilities within close proximity to vehicle paths (i.e., streets or off-road trails).

That noise experienced at the operator's ear during exposure to airflow past the head. All of these exposure conditions occur for various operational modes of the motorcycle.

In general, products have a range of possible operational modes with noise emission characteristics dependent on how they operate. The key to deciding upon the mode or modes of operation of a vehicle that should be specified for noise test purposes hinges on the knowledge of how the vehicle is "normally" operated. In order to determine "normal operation" a usage survey should be conducted. Such data providing the correspondence between acoustic output of various motorcycles under various operations do not presently exist.

In selecting appropriate operating procedures for use in motorcycle noise tests, it is important to consider which of the major noise sources -- engine (including exhaust, intake and mechanical factors), transmission (including internal and external drive system components -- gearset, clutch and chain or gear linkage, etc.) and aerodynamic flow/tires -- are important during the various modes of operation of motorcycles, in order to be sure that the measurement methodology and operating limitations provide equitable tests. For instance, at low speed acceleration, as indicated by most of the test procedures, engine noise and that part of transmission noise associated with the particular gear in which the vehicle is operated is predominant. Although it is normally assumed that the results of these test procedures are essentially unaffected by tire/road interaction noise, at higher speeds aerodynamic flow/tire noise levels may become the dominate source of noise (especially in and around the motorcycle and the rider). Knowledge of the controlling source(s) is also important in this case for selecting microphone height, etc.

There is also a need to establish correlations between the noise emitted by motorcycles in various operational modes and the noise emitted during simulated operations which may be much more convenient from a testing point of view -- for example, a stationary run-up test instead of the acceleration passby test specified by most of the existing measurement procedures.

As previously noted, a number of parameters can affect the mechanical performance of these lightweight vehicles, which may in turn affect the results of acoustic measurements, particularly measurements made during maximum performance maneuvers such as acceleration passbys.

In the acceleration test for example, the speed of the vehicle (and hence the engine) at any time (in a particular gear) is determined by engine power output, the mass being accelerated and frictional losses in the system. Thus, equitable tests of acoustic output can be made only when engine performance, accelerated mass and frictional losses are comparable with "in use" expectations.

It should be expected then, that the vehicle operation portion of the methodology must incorporate specifications or rider limitations which will yield suitable vehicle operation.

8.3. Quantity Measured

The EPA "levels document" utilizes the equivalent A-weighted sound level as the appropriate quantity to use in characterizing community noise exposure. Thus, it is necessary that (one of) the quantity (or quantities) measured in a regulation on a specific noise source, e.g., a motorcycle, could be easily and directly related to the contribution which the source makes to the equivalent A-weighted sound level for typical listeners. Therefore, it seems appropriate to measure the A-weighted sound level at a particular microphone location during a vehicle passby. This measure of source strength can then be used to estimate the contribution which that source makes to the equivalent sound level at some other location. For example, data obtained on trucks and automobiles indicate that the sound level 50 feet (15.2 m) to the side of the vehicle centerline can be used fairly reliably to predict noise levels further from the vehicle. This is expected to be the case for motorcycles as well. However, it should be noted that since motorcycle noise producing components are exposed, they may generate a more complex acoustical field with potentially greater directivity which may make estimation of noise in the community more difficult.

There is a hazard associated with the use of A-weighted level only in the measurement procedure and/or regulation. The A-weighting filter places very little emphasis on low frequency sounds; therefore, the noise control treatment which is designed to control mid and high frequency sounds may or may not change low frequency sound levels -- thus, creating a dominance of low frequency noise levels. For this reason, considerations of other weighting networks, in addition to the A-weighted system, should be made prior to regulation of the source output.

It is questionable as to whether or not the maximum noise level at 50 feet (15.2 m) can be used to infer the contribution which a motorcycle passby makes to the equivalent sound level at distances much closer to the motorcycle -- distances which correspond to the vehicle operator and other pedestrians. Some attempts to measure noise at the operator's ear, for example, have indicated that aerodynamic noise is a very significant factor, even at moderate speeds (30-40 mph). If this is the case, then factors which affect flow around the operator's head, such as helmet design and fit, windshield, etc., can be expected to be significant in this measurement, although of course they would not affect a measurement at 50 ft. (15.2 m).

In order to ascertain the contribution which motorcycles make to the "reverberant level" in city streets with tall buildings on either side, it is necessary to consider whether or not the noise emission from motorcycles is highly directional. If so, it might be necessary to measure the noise level in several directions from the motorcycle.

Hopefully, adequate correlations can be established to enable collapsing the number of measurement positions to a very few. Similarly, it may be hoped that only maximum noise levels need to be measured for the several operational modes of interest. However, it seems evident that a comprehensive experimental program is needed to guide and justify such simplification.

The motorcycle (considering present typical levels and use periods) presents a potentially serious hearing damage threat to the rider and passenger. As a result, it is expected that regulation of noise output will have to consider this aspect of the problem. In the event that it is concluded in the regulatory process that a level for noise at the operator's ear must be determined, then considerable investigation of measurement techniques will be required. In particular, it should be noted that wind, which may or may not represent a significant source to the operator, will certainly represent a significant measurement problem, if the vehicle is in motion.

8.4. Acoustic Environment

There is general agreement that the noise emission from motor vehicles should be measured in a free field over a reflecting plane. If a 50 foot (15.2 m) measurement distance is utilized a rather large open area is needed plus a roadway of sufficient length to accommodate the specified operational mode(s) of the vehicle.

Although considerable uniformity has been achieved by the SAE, CHP and ISO in defining standard noise measurement procedures, there remain significant variations between noise measurements made at different sites, or at different times at the same site. Experience to date with measurement of motor vehicle noise at 25 to 50 foot (7.5 to 15.2 m) distances, for typical microphone heights, indicates that the levels measured are sensitive to the characteristics of surrounding ambient conditions (air temperature, humidity, atmospheric pressure), to the characteristics of the reflecting plane (acoustic impedance, flatness), to temperature gradients above the ground plane (which depend on present and past air temperatures, sunlight, and wind velocities as well as the emittance and absorptance of the reflecting plane), and to atmospheric inhomogenieties (wind velocity, wind gradients, and local turbulance). All of these factors may influence the generation of noise by the propulsion system and associated auxiliary equipment, the radiation from the source into the surrounding atmosphere and/or the propagation from the immediate vicinity of the vehicle to the measurement location.

Since these factors influence reliable measurements of many of the sources which EPA is, or will be, regulating, there is a need for the various environmental and site effects to be systematically investigated so that: (1) noise measurements taken at a given site can be corrected to standard environmental conditions, (2) noise measurements taken at different sites under the same environmental conditions can be correlated and, therefore (3) noise measurements taken at different sites under any environmental conditions can be correlated. If correction factors can not be demonstrated to be feasible then there is a need for a site calibration procedure and/or definition of limiting test conditions.

8.5. Instrumentation

The instrumentation section of the regulation should require equipment meeting the Type 1 requirements of American National Standard Specifications for Sound Level Meters, S1.4-1971[14]. In addition, pertinent sections of American National Standard Methods for the Measurement of Sound Pressure Levels, S1.13-1971[20] should be incorporated. For instruments for which standards do not exist, or where existing standards are not sufficient, the regulation should include specific criteria for evaluating the performance of such devices. For example, a critical deficiency in existing standards is that the response of instrumentation to transient signals, e.g., vehicle passbys, is not well defined. Further, the exhaust signature of many small engines produces a very high crest-factor signal for which many commercially available detection circuits have notably deficient response. Suitable standards defining these characteristics do not exist.

It is important to clearly state in the regulation the allowable tolerance for frequency response, environmental effects, harmonic distortion, etc., which the instruments are required to meet. These specifications should be applied not only to specific components of the system but to the overall system as well. The overall system measurement error should not be degraded below that allowed for direct measurements made with sound level meters regardless of the instrumentation configuration.

In addition, overall system calibration should be required at frequent stipulated intervals. The fact that each component of a system appears satisfactory does not ensure that the system performance will be acceptable.

8.6. Alternative Test Procedures

It is not seriously suggested that a motorcycle noise regulation should explicitly require measurements corresponding to all possible exposure conditions coupled with all possible motorcycle operational modes. However, it is important to consider the prevalance of each condition, perhaps in terms of its contribution to L_{eq} or L_{dn}, when evaluating the effects of motorcycle noise on the populace. If several exposure conditions are found to be important, hopefully correlations can be developed which will enable collapsing the several cases into one or two measurements.

Because of the space, weather and other constraints associated with the existing low speed acceleration test procedures, it seems appropriate to investigate alternative procedures which would be simpler to perform yet correlatable with the "real world" situation. The Federal International Motorcyclist presently utilizes a stationary motorcycle test procedure with the engine stablized at some pre-determined rpm level as the basis for determining permissible noise levels for racing motorcycles. The Bureau of Motor Carrier Safety also has a similar stationary test procedure except that the engine is stabilized at its maximum rated or governed engine speed (high idle) as the basis for regulating truck and bus (interstate) interior cab noise. In addition, present Federal noise certification procedures for interstate motor carriers specifies a stationary run-up test -- the engine is accelerated as rapidly as possible to its governed speed at wide open throttle (transmission in neutral). One of the main difficulties with stationary test procedures is the fact that gear train associated noise is not evaluated. Also, stationary procedures such as the stationary run-up test are limited in their applicability -- in this case the test can only be utilized on vehicles with governed engines. Although stationary tests probably take less time to perform and require less space (smaller test sites), all of the weather constraints which limit testing when the passby method is utilized would also be a problem with the stationary test. Further, recent data indicates an extremely poor correlation between stationary run-up tests and either passby or in use tests for racing cycles.

Since the weather is a major limiting factor for all outdoor tests, it would seem logical to investigate the feasibility of indoor testing. If indoor testing were to be chosen as part of a standard or regulation, a testing facility would have to be specified in great detail and identical facilities would have to be constructed by each manufacturer -- be he small or large. It would appear to be prohibitively expensive to construct a facility to allow for 15.2 meter measurements; yet, measurements any closer than 15.2 meter would be questionable without extensive research to provide insight into the near field/far field effects and to establish the correlation between the results obtained according to such procedures with the community noise exposure from motorcycle operation. Also, the practical problem of removing the heat and exhaust fumes from the operating vehicle would have to be dealt with.

Any alternative procedure will have pros and cons associated with them; but, they will have almost no data base or experience base to back them up. Much research would be necessary before such procedures could be utilized as a measurement methodology for regulating the environmental impact or operator-at-ear noise produced by motorcycles.

9. Appendix A: A Discussion of Motorcycle Subsource Noise[12/]

Exhaust System Noise

Exhaust noise is generated by the rapid release of high temperature and pressure combustion gases when the exhaust valve or port opens. In addition to the discharge noise -- noise radiated to the atmosphere at the tail pipe outlet -- this rapid release of pressure excites oscillations of the muffler shell and exhaust and tail pipe surfaces which are radiated into the atmosphere as noise. A running engine can repeat this process over a hundred times per second, with the resultant perceived noise appearing as a staccato or smooth tone depending on engine type and speed. Transmission loss through the pipes is an additional noise source.

The primary frequency components of exhaust noise are dependent upon engine speed, number of cylinders, exhaust system configuration (single or dual exhausts) and whether the engine is a 2-cycle or 4-cycle engine. For 2-cycle engines high frequency spectra are typical, while the 4-cycle engine exhibits more low frequency content. The amplitude of exhaust noise is directly dependent upon ignition timing, throttle setting and engine load (pressure in the cylinder when the valve opens).

Mufflers or resonators are typically utilized to control exhaust discharge noise. The performance of these devices is very dependent upon other acoustic elements within the system such as the engine and the length and diameter of both the exhaust and tail pipe. A major consideration in engine performance for 4-cycle motorcycle engines over a specific rpm range is exhaust pipe length. By virtue of their design constraints, these machines must emphasize lightweight, compact construction -- such requirements are not directly compatible with the basic principle of 4-cycle muffler tuning which equates the degree of silencing to gross muffler volume. Performance and economy are directly affected by silencing, as these machines rely on low back pressure to achieve competitive horsepower/weight ratios. Thus, mufflers, in addition to providing effective noise reduction must also be designed to provide a tolerable back pressure on the engine.

Two-stroke motorcycle engines present less of an exhaust silencing problem since they are designed to incorporate an expansion chamber system, in which much of the acoustic energy is reflected back into the engine. A well designed 2-cycle exhaust muffler system will actually increase power while at the same time reduce noise levels.

Most of the early success in exhaust noise reduction involved improvements in exhaust silencing. Techniques involving using large volume, more restrictive sound baffles in the mufflers, multiple mufflers, and the interconnection of header pipes on multicylinder engines have reduced exhaust outlet noise appreciably.

[12/] The material in this appendix was mainly derived from Wyle Laboratory reports to EPA[3,21] on transportation noise and a technology and cost information study on control of motorcycle noise.

• Air Intake Noise

Engine air-intake noise is produced by the opening and closing of the intake valve which causes the volume of air in the system to pulsate.

Intake systems are similar to exhaust systems in that the components and problems are much the same; however, each intake system must be treated individually since both the frequency and amplitude of intake noise varies with engine type.

With the reduction of exhaust noise over the past few years, noise radiated through the intake system is nearly equal to the noise radiated through the exhaust system for all motorcycle sizes. They both correspond to throttle opening, engine speed, number of cylinders, engine displacement and engine load, and are the two predominant noise sources for most modes of operation. Two-cycle engines which, for a given speed, induct nearly twice the volume of air as four-cycle engines of equivalent size, have traditionally generated high intake levels, but recent improvements in silencing practice have reduced intake levels to those of the exhaust. Also, there is some indication that, as exhaust muffler "back pressure" increases, intake noise levels may also increase.

The reduction of intake noise is affected in a manner similar to that employed for the exhaust. Techniques such as the reduction of the inlet cross-sectional area to the minimum required for adequate intake supply, the use of noise baffles along the intake tract, large rubber enclosed plenum volumes along the intake tract, and positioning of inlet apertures behind filtration elements in acoustically shielded portions of the machine are but a few of the methods used in intake noise reduction.

• Engine (mechanical)

The engine and transmission drive system form a complex acoustical system composed of a large number of sources, the most important of which is the characteristic mechanical clatter and ringing of an air cooled engine. Mechanical noise directly transmitted from within the engine results from the combustion process which produces rapid changes in pressure in the cylinder which in turn causes the actual striking together of engine parts, such as piston slap, valve and valve train clatter (present in four-cycle engines only), gear meshing, and noise from the roller and ball bearings widely used in motorcycle engines. Secondary mechanical noise is radiated from vibrating engine surfaces, such as cooling fins and casings, which become excited by internal engine operation and combustion pulses. A final source of engine noise is directly transmitted combustion noise which is considered to be of an insignificant level in relation to the other major sources for most modes of operation.

Transmission noise originates from the internal and external drive system components. Internal sources consist of the gearset and primary drive. The gearset noise originates with the meshing and movements of gears and bearings within the gear ratio assembly. This may be apparent under both load and no load conditions. The primary drive system, comprised of the clutch and chain or gear linkage between engine crankshaft and gear set, creates additional noise which is at times coupled with vibration noise from clutch components. The noise generated by the primary drive system is usually lower than that produced by the external drive chain. The transmission system subsources tend to excite the external gearset cases, primary cases, and other vehicle parts which radiate additional sound. A disproportionate reduction of mechanical noise may be necessary when considering reduction of total motorcycle noise in order to prevent conditions such as the "bolt-in-a-can" effect.

To reduce total noise levels for the majority of large machines requires significant reduction of mechanical noise from both the engine and transmission drive system components. Techniques involving encapsulation of engine, elastic isolation of engine and drive units, increased damping of engine and transmission cases and drive chain enclosures have been but a few of the many methods considered for quieting engine mechanical noise.

Aerodynamic Noise

This source of noise is most prevalent at high vehicle speed and is created by turbulent passage of air in and around the motorcycle and its rider. Aerodynamic sources along with tire/roadway interactions are somewhat negligible in overall contributions to present day total motorcycle noise levels, but future requirements for reduced noise levels may require serious investigation of these sources.

Turbulence caused by the motion of the machine through air may be reduced in a number of ways -- such as utilizing solid or thick spoked cast alloy wheels instead of wire spoked wheels and streamlining or routing the maze of cables, levers, and wires through the vehicle components.

Tire-Road Interaction Noise

The physical mechanisms of the production of noise by the tire-road interaction process are not well understood. The general consensus is that air pumping (entrapment and release of air from the tire tread cavities) and vibration of the tire carcass are the major mechanisms contributing to the generation and radiation of acoustic energy. Even though the effects of tread design (rib, cross bar), road surface, wear, and load on the noise levels produced are known, the existing data do not provide the basis for the design of quieter tires. Little research has been specifically conducted regarding motorcycle tire noise due to the low significance of the problem.

10. Appendix B. Existing and Proposed Noise Measurement Procedures Pertinent to Motorcycles

SOUND LEVELS FOR MOTORCYCLES - SAE J331a — SAE Recommended Practice 13/

Report of Vehicle Sound Level Committee and Motorcycle Committee
Approved May 1975.

1. SCOPE - This SAE Recommended Practice establishes the test procedure, environment, and instrumentation for determining sound levels typical of normal motorcycle operation.

2. INSTRUMENTATION

2.1 The following instrumentation shall be used, where applicable:

2.1.1 A sound level meter which meets the Type 1 or S1A requirements of American National Standard Specification for Sound Level Meters, 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 requirements of SAE Recommended Practice, Qualifying a Sound Data Acquisition System - J184.

2.1.2 An acoustic calibrator with an accuracy of ± 0.5 dB (see paragraph 7.4.4).

2.1.3 A calibrated engine speed tachometer having the following characteristics:

(a) Steady-state accuracy of better than 1%.

(b) Transient response: Response to a step input will be such that within 10 engine revolutions the indicated rpm will be within 2% of the actual rpm.

2.1.4 A speedometer with steady-state accuracy of at least ± 10%.

2.1.5 An anemometer with steady-state accuracy of at least ± 10% at 19 km/h (12 mph).

2.1.6 An acceptable wind screen may be used with the microphone. To be acceptable, the screen must not affect the microphone response more than ± 1 dB for frequencies of 20-4000 Hz or ± 1-1/2 dB for frequencies of 4000-10,000 Hz.

3. TEST SITE

3.1 The test site shall 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 30m (100 ft) radius of the microphone location and the following points on the vehicle path:

(a) The microphone point

(b) A point 15m (50 ft) before the microphone point.

(c) A point 15m (50 ft) beyond the microphone point.

3.2 The measurement area within the test site shall meet the following requirements and be laid out as described:

3.2.1 The surface of the ground within at least the triangular area formed by the microphone location and the points 50 ft (15.2m) prior to and 50 ft (15.2m) beyond the microphone point shall be dry concrete or asphalt, free from snow, soil or other extraneous material.

3.2.2 The vehicle path shall be of relatively smooth, dry concrete or asphalt, free of extraneous materials such as gravel, and of sufficient length for safe acceleration, deceleration and stopping of the vehicle.

3.2.3 The microphone shall be located 15m (50 ft) from the centerline of the vehicle path and 1.2m (4 ft) above the ground plane.

3.2.4 The following points shall be established on the vehicle path:

(a) Microphone point-a point on the centerline of the vehicle path where a normal through the microphone location intersects the vehicle path.

(b) End point-a point on the vehicle path 30m (100 ft) beyond the microphone point.

(c) Acceleration point-a point on the vehicle path 7.5m (25 ft) prior to the microphone point.

3.2.5 The test area layout in Fig. 1 shows a directional approach from left to right with one microphone location, for purposes of clarity. Sound level measurements are to be made on both sides of the vehicle; therefore, it will be necessary to establish either a second microphone point on the opposite side of the vehicle path with a corresponding clear area or end points and acceleration points for approaches from both directions.

4. TEST WEIGHT

4.1 At the start of the test series, the vehicle shall be filled with fuel and lubricant to not less than 75% of capacity.

4.2 The combined weight of the test

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rider and test equipment used on the vehicle shall be not more than 79 kg (175 lb) nor less than 75 kg (165 lb). Weights shall be placed on the vehicle saddle behind the driver to compensate for any difference between the actual driver/equipment load and the required 75 kg (165 lb) minimum.

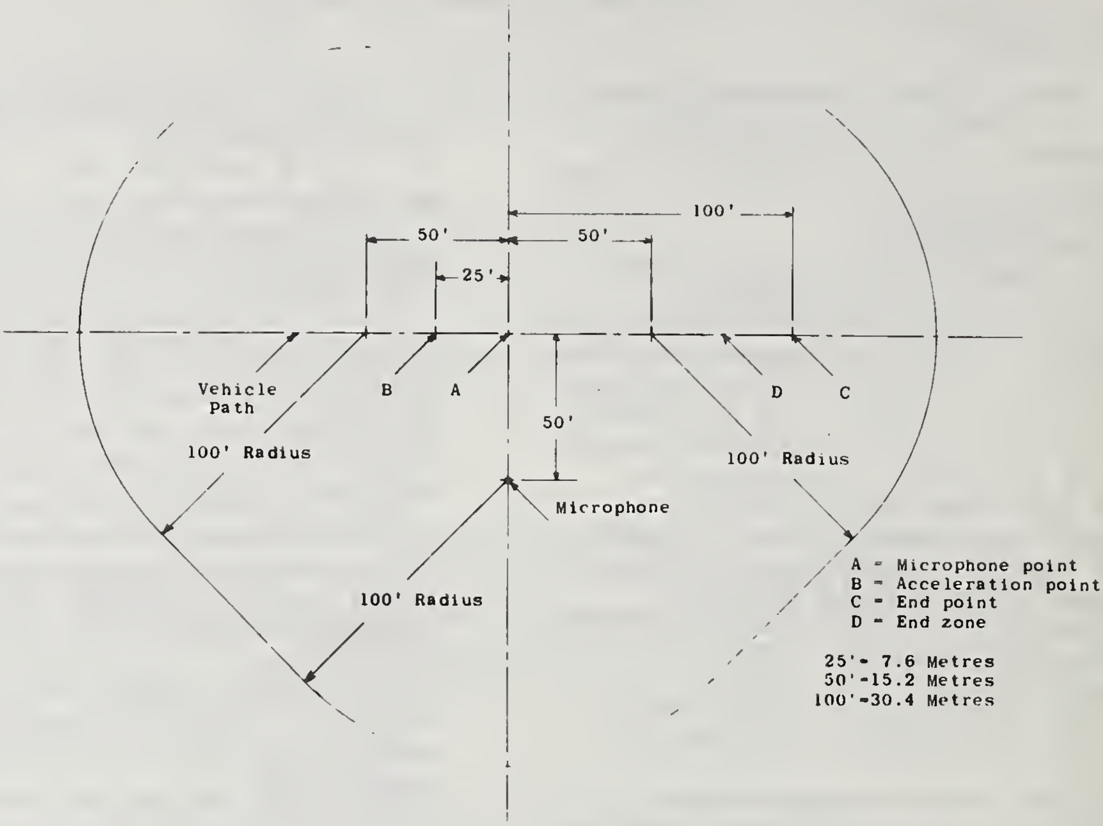


FIG. 1

5. PROCEDURE

5.1 The vehicle shall use second gear unless during the test under acceleration the engine speed at maximum rated net horsepower is reached before the vehicle reaches a point 7.5m (25 ft) beyond the microphone point, in which case the vehicle shall be tested in third gear.

5.2 For the test under acceleration, the vehicle shall proceed along the vehicle path at a constant approach speed which shall correspond to either an engine speed of 60% of the engine speed at maximum rated net horsepower or a vehicle speed of 48 km/h (30 mph), whichever is slower. When the front of the vehicle reaches the acceleration point, rapidly and fully open the throttle and accelerate until the front of the vehicle is 30 m (100 ft) beyond the microphone point, or until the engine speed at maximum rated horsepower is reached, at which point the throttle shall be closed. Wheel slip which effects the maximum sound level shall be avoided.

5.3 When excessive or unusual noise is noted during deceleration, the following test shall be performed with sufficient runs to establish maximum sound level under deceleration:

5.3.1 For the test under deceleration, the vehicle shall proceed along the vehicle path at an engine speed at maximum rated net horsepower in the gear selected for the test under acceleration. At the end point, the throttle shall be rapidly and fully closed, and the vehicle allowed to decelerate to an engine speed of one-half of the rpm at maximum rated net horsepower.

5.4 Sufficient preliminary runs to familiarize the driver and to establish the engine operating conditions shall be made before measurements begin. The engine temperature shall be within the normal operating range prior to each run.

6. MEASUREMENTS

6.1 The sound level meter shall be set for fast response and for the A-weighting network.

6.2 The meter shall be observed while the vehicle is accelerating or decelerating. Record the highest sound level obtained for the run, ignoring unrelated peaks due to extraneous ambient noises. All values shall be recorded.

6.3 At least six measurements shall be made for each side of the vehicle. Sufficient measurements shall be made until at least four readings from each side are with 2 dB of each other. The highest and the lowest readings shall be discarded; the sound level for each side shall be the average of the four, which are within 2 dB of each other. The sound level reported shall be for that side of the vehicle having the highest sound level.

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

6.5 Wind speed at the test site during tests shall be less than 19 km/h (12 mph).

7. GENERAL COMMENTS

7.1 Technically competent personnel should select equipment and the tests should be conducted only by trained and experienced persons familiar with the current techniques of sound measurement.

7.2 While making sound level measurements, not more than one person other than the rider and the observer reading the meter shall be within 15m (50 ft) of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

7.3 The test rider should be fully conversant with and qualified to ride the machine under test and be familiar with the test procedure.

7.4 Proper use of all test instrumentation 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. Specific items to be considered are:

7.4.1 The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.

7.4.2 The effects of ambient weather conditions on the performance of all instruments (for example, temperature, humidity and barometric pressure).

7.4.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

7.4.4 Proper acoustical calibration procedure to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

8. REFERENCES

Suggested reference material is as follows:

8.1 ANSI S1.1 - 1960, Acoustical Terminology.

8.2 ANSI S1.2 - 1962, Physical Measurement of Sound.

8.3 ANSI S1.4 - 1971, Specification for Sound Level Meters.

8.4 ANSI S1.13 - 1971, Method of Measurement of Sound Pressure Levels.

8.5 SAE J184, Qualifying a Sound Data Aquisition System.

8.6 SAE J47, Maximum Sound Level Potential for Motorcycles.

CALIFORNIA HIGHWAY PATROL NOISE MEASUREMENT PROCEDURE
EDITED FOR NEW VEHICLES

ORDER ADOPTING, AMENDING, OR REPEALING
REGULATIONS OF THE DEPARTMENT OF THE
CALIFORNIA HIGHWAY PATROL

After proceedings had in accordance with the provisions of the Administrative Procedure Act (Gov. Code, Title 2, Div. 3, Part 1, Chapter 4.5) and pursuant to the authority vested by Section 2402 of the Vehicle Code, and to implement, interpret, or make specific Sections 23130 and 27160 of the Vehicle Code, the Department of the California Highway Patrol hereby adopts, amends, or repeals regulations in Chapter 2, Title 13, California Administrative Code, as follows:

(1) Amends Article 10, Subchapter 4 to read:

Article 10. Vehicle Noise Measurement

1040. Scope of Regulations. This article contains procedures implementing Section 23130 of the Vehicle Code which applies to the measurement of noise from motor vehicles and combinations of vehicles subject to registration when operated on a highway and Section 27160 of the Vehicle Code which applies to the measurement of noise from new motor vehicles offered for sale.

1041. Definitions. The following definitions shall apply wherever the terms are used in this article:

(a) First Gear. The "first gear" is the highest numerical gear ratio of the transmission which is commonly referred to as low gear.

(b) Maximum RPM. The "maximum rpm" is the maximum governed engine speed, or if ungoverned, the rpm at maximum engine horsepower as determined by the engine manufacturer in accordance with the procedures in SAE J245, April 1971.

(c) Vehicle Reference Point. The "vehicle reference point" is the location on the vehicle used to determine when the vehicle is at any of the points on the vehicle path. The vehicle reference point shall be the front of the vehicle unless such position is more than 16 ft from the exhaust outlet, in which case both the front of the vehicle and the exhaust outlet shall be used as reference points.

1042. Personnel. Persons selected to conduct noise measurement testing or to measure noise level of vehicles operated on a highway shall have been trained and qualified in the techniques of sound measurement and the operation of sound measuring instruments.

1043. Instrumentation. Equipment used in making vehicle noise measurements shall be selected by technically trained personnel and shall meet the following requirements:

(a) Sound Level Meter. The sound level meter shall meet the requirements of ANSI Standard S1.4-1971 for Types 1, 2, or S2A.

(b) Sound Level Calibrator. The sound level calibrator shall calibrate the entire sound level meter with an acoustic calibrator of the coupler-type.

(c) Tachometer. A calibrated engine speed tachometer shall be used to determine when maximum rated rpm is attained in conducting the tests specified in Section 1046 of this code.

(d) Anemometer. An anemometer shall be used to measure the wind speed at the test site when conducting tests specified in Section 1046 of this code.

1044. Noise Measurement Sites. Noise measurement sites shall be selected to meet location, ground condition, and roadway surface requirements in the following subsections (a) and (b):

(a) Measurement Sites for Vehicles on the Highway.

(b) Measurement Sites for New Motor Vehicles. Sites for measuring noise from new motor vehicles to determine compliance with Section 27160 of the Vehicle Code shall meet the following conditions:

(1) Location. The location shall be a flat open space free of large vertical sound-reflecting surfaces such as signboards, buildings hillsides, or trees within 100 ft of the microphone and within 100 ft of the centerline of the path of the vehicle from the point where the throttle is opened to the point where the throttle is closed.

(2) Ground Condition. The ground surface between the microphone and the path of the vehicle shall be asphalt or concrete free of powdery snow, l o e soil, or ashes.

(3) Roadway Surface. The surface over which the vehicle travels shall be dry and relatively smooth concrete or asphalt pavement free of extraneous material.

1045. Microphone and Personnel Positions. The microphone for the sound level meter and the personnel involved in all types of vehicle noise measurements shall be positioned as follows:

(a) Microphone Location. The microphone shall be located 50 $\pm$ 1 ft from the centerline of the lane of travel of the vehicle at a height of 4 $\pm$ 1/2 ft above the plane of the roadway surface.

(b) Microphone Orientation. The microphone shall be oriented in relation to the source of the sound in accordance with the instrument manufacturer's instructions. Where the instruction manual is vague or does not include adequate information, a specific recommendation shall be obtained from the manufacturer.

(c) Technician Location. The technician making direct readings of the meter shall be positioned in relation to the microphone in accordance with the instrument manufacturer's instructions. Where the instruction manual is vague or does not include adequate information, a specific recommendation shall be obtained from the manufacturer.

(d) Bystander Location. During noise measurements, bystanders shall remain at least 50 ft from the microphone and the vehicle being measured, except for a witness or trainee, who may be positioned beyond the technician on a line with the technician and the microphone.

1046. Operation of New Motor Vehicles. New motor vehicles tested to determine compliance with Section 27160 of the Vehicle Code shall be operated in conjunction with any auxiliary equipment that would be in use while the vehicle is operated on the highway, including but not limited to cement mixers, refrigerator units, and garbage compactors.

(a) Heavy Trucks, Truck Tractors, and Buses.

(b) Light Trucks, Truck Tractors, Buses, and Passenger Cars.

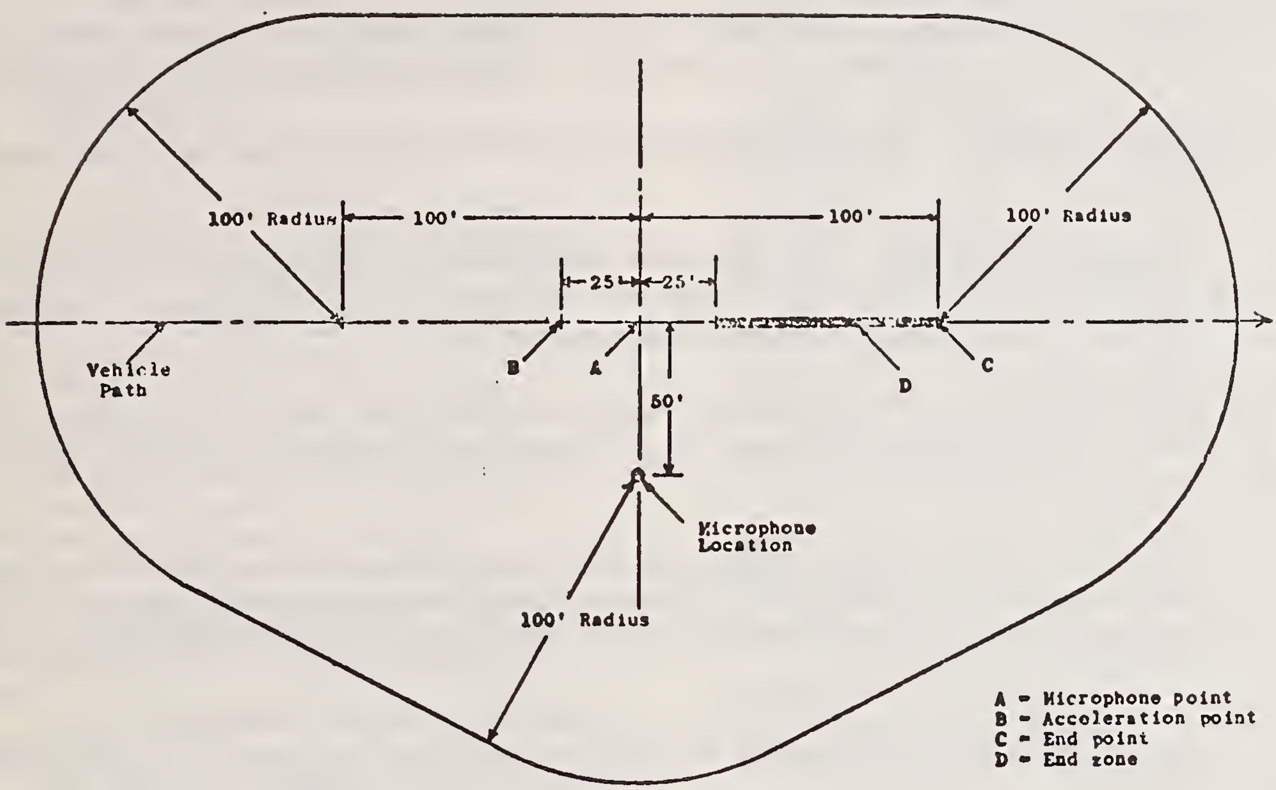
(c) Motorcycles. The test procedure for motorcycles shall be as follows:

(1) Test Area Layout. The test area layout for motorcycles shall be the same as specified in subsection (b) (1) and Figure 3 for light trucks, truck tractors, buses, and passenger cars. (See next page.)

(2) Gear Selection. Motorcycles shall be operated in second gear. Vehicles which reach maximum rpm at less than 30 mph or before a point 25 ft beyond the microphone point shall be operated in the next higher gear.

(3) Acceleration. The vehicle shall proceed along the test path at a constant approach speed which corre ponds either to an engine speed of 60% of maximum rpm or to 30 mph, whichever is lower. When the vehicle reference point reaches the acceleration point, the throttle shall be fully opened. The throttle shall be held open until the rear of the vehicle is approximately 100 ft beyond the microphone or until the maximum rpm is obtained, at which point the throttle shall be gradually closed. Wheel slip shall be avoided during this test.

(4) Engine Temperature. The engine temperature shall be within normal operating range before each test run.



Test Area Layout. The test area shall include a vehicle path of sufficient length for safe acceleration, deceleration, and stopping of the vehicle. The vehicle path (shown with only one directional approach in Figure 3 for purposes of clarification) shall be marked with the following zone and points:

(A) Microphone point - the location on the centerline of the vehicle path that is closest to the microphone.

(B) Acceleration point - a location 25 ft before the microphone point.

(C) End point - a location 100 ft beyond the microphone point.

(D) End zone - the last 75-ft distance between the microphone point and the end point.

Figure 3. Test Area Layout for Light Trucks, Truck Tractors, Buses, Passenger Cars and Motorcycles.

(d) Deceleration. Tests during deceleration shall be conducted when deceleration noise appears excessive. The vehicle shall approach the end point from the reverse direction a maximum rpm in the same gear selected for the tests during acceleration. At the end point, the throttle shall be closed and the vehicle shall be allowed to decelerate to 1/2 of maximum rpm.

1047. Meter Operation. The sound level meter shall be operated in accordance with the instrument manufacturer's instructions and as follows:

(a) Meter Setting. The A-weighting network and the fast meter response shall be used.

(b) Calibration Check. An external calibration check shall be made before and after each period of use and at intervals not exceeding 2 hr when the instrument is used longer than a 2-hr period.

(c) Meter Reading. The reading recorded shall be the highest sound level obtained as the vehicle passes by, disregarding unrelated peaks due to extraneous ambient noises.

(d) Ambient Sound. Measurements shall be made only when the A-weighted ambient sound level, including wind effects, due to all sources other than the vehicle being measured, is at least 10 dB(A) lower than the sound level of the vehicle.

(e) Wind. Measurements shall be made only when the wind velocity is less than 12 mph.

1048. Vehicle Noise Level. The measured noise level of a vehicle shall be reported as follows:

(a) Vehicles on the Highway.

(b) New Motor Vehicles. The sound level readings for determining compliance of new motor vehicles with Section 27160 of the Vehicle Code shall be obtained after sufficient preliminary runs to enable the test driver to become familiar with the operation of the vehicle and to stabilize engine operating conditions.

> (1) At least four measurements shall be made from each side of the vehicle. When the exhaust outlet is more than 16 ft from the driver's position, at least two runs in each direction shall be performed with each of the reference points described in Section 1041 (c) of this code.
>
> (2) The A-weighted sound level for each side of the vehicle shall be the average of the two highest readings on that side which are within 2 dB(A) of each other. The noise level reported for the vehicle shall be the sound level of the loudest side.

Report of Vechile Sound Level Committee and Motorcycle Committee approved May 1975.

1. SCOPE

This SAE Recommended Practice establishes the test procedure, environment and instrumentation for determining maximum sound level potential for motorcycles.

2. INSTRUMENTATION

2.1 The following instrumentation shall be used, where applicable:

2.1.1 A sound level meter which meets the Type 1 or S1A requirements of American National Standard Specification for Sound Level Meters, 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 requirements of SAE Recommended Practice, Qualifying a Sound Data Acquisition System -J184.

2.1.2 An acoustic calibrator with an accuracy of ± 0.5 dB (see paragraph 6.4.4)

2.1.3 A calibrated engine speed tachometer having the following characteristics:

(a) Steady-state accuracy of better than 1%

(b) Transient response: Response to a step input will be such that within 10 engine revolutions the indicated rpm will be within 2% of the actual rpm.

2.1.4 An anemometer with steady-state accuracy within $\pm$ 10% at (19 km/h) 12 mph.

2.1.5 An acceptable wind screen may be used with the microphone. To be acceptable, the screen must not affect the microphone response more than ± 1 dB for frequencies of 20-4000 Hz or $\pm 1\text{-}1/2$ dB for frequencies of 4000-10,000 Hz.

3. TEST SITE

3.1 The test site shall 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 (30.4m) (100ft) radius of the microphone location and the following points on the vehicle path:

(a) The microphone point.

(b) A point (15.2m) (50 ft) before the microphone point.

(c) A point (15.2m) (50 ft) beyond the microphone point.

3.2 The measurement area within the test site shall meet the following requirements and be laid out as described:

3.2.1 The surface of the ground within at least the triangular area formed by the microphone location and the points (15.2m) 50 ft prior to and (15.2m) 50 ft beyond the microphone point shall be dry concrete or asphalt, free from snow, soil or other extraneous material.

3.2.2 The vehicle path shall be of relatively smooth, dry concrete or asphalt, free of extraneous materials such as gravel, and of sufficient length for safe acceleration, deceleration, and stopping of the vehicle.

3.2.3 The microphone shall be located (15.2m) (50 ft) from the centerline of the vehicle path and (1.2m) (4 ft) above the ground plane.

3.2.4 The following points shall be extablished on the vehicle path:

(a) Microphone point-a point on the centerline of the vehicle path where a normal through the microphone location intersects the vehicle path.

(b) End point-a point on the vehicle path (7.6m) (25 ft) beyond the microphone point.

(c) Acceleration point-a point on the vehicle path at least (7.6m) (25 ft) prior to the microphone point established by the method described in paragraph 4.1.

3.2.5 The test area layout in Fig. 1 shows a directional approach from left to right with one microphone location for purposes of clarity. Sound level measurements are to be made on both sides of the vehicle; therefore, it will be necessary to establsh either a second microphone location on the opposite side of the vehicle path with a corresponding clear area or end points, and acceleration points for approaches from both directions.

4. PROCEDURE

4.1 To establish the acceleration point, the end point shall be approached in low gear from the reverse direction at a constant road speed obtained from 60% of the engine speed at maximum rated

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net horsepower. When the front of the vehicle reaches the end point, the throttle shall be rapidly and fully opened to accelerate past the microphone point under wide-open throttle. By trail, the lowest transmission gear shall be selected that will result in the vehicle traveling the shortest distance from the end point to the place where the engine speed at maximum rated net horsepower is reached, but which is not less than (7.6mm)(24ft) past the microphone point. The location of the front of the vehicle on the vehicle path when the engine speed at maximum rated net horsepower is attained shall be the acceleration point for test runs to be made in the opposite direction.

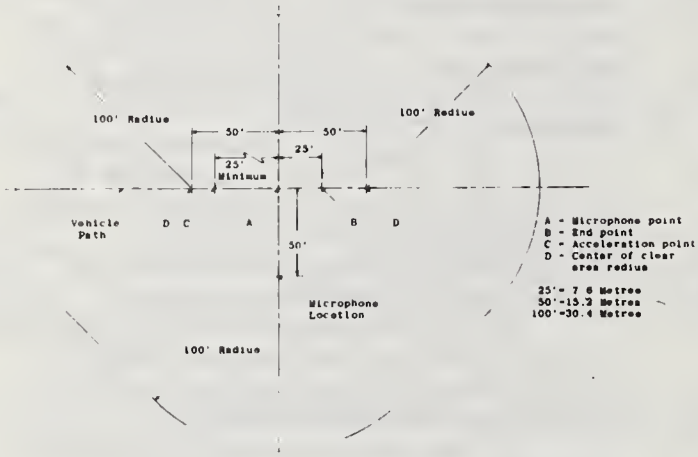

FIG. 1

4.1.1 When the procedure described in paragrah 4.1 results in a dangerous or unusual operating condition such as wheel spin, front wheel lifting, or other unsafe conditions, the next higher gear shall be selected for the test and the procedure rerun to establish the acceleration point. In any event, the procedure shall result in the vehicle being at the end point when the engine speed at maximum rated net horsepower is attained.

4.2 For the test under acceleration, the vehicle shall proceed along the vehicle path at a constant approach speed in the gear selected in paragraph 4.1 and at 60% of the engine speed at maximum rated net horsepower. When the front of the vehicle reaches the acceleration point, the throttle shall be rapidly and fully opened. Full acceleration shall continue until the engine speed at maximum rated net horsepower is reached, which shall be at the end point, at which time the throttle shall be closed. Wheel slip which affects the maximum sound level shall be avoided, and the manufacturer's safe maximum engine speed shall not be exceeded.

4.3 When excessive or unusual noise is noted during deceleration, the following test shall be performed with sufficient runs to establish maximum sound level under deceleration.

4.3.1 For the test under deceleration, the vehicle shall approach the end point from the reverse direction at the engine speed at maximum rated horsepower in the gear selected for the test under acceleration. At the end point, the throttle shall be rapidly and fully closed and the vehicle shall be allowed to decelerate to an engine speed of 1/2 the rpm at maximum rated net horsepower.

4.4 Sufficient preliminary runs to familiarize the driver and to establish the engine operating conditions shall be made before measurements begin. The engine temperature shall be within the normal operating range prior to each run.

5. MEASUREMENTS

5.1 The sound level meter shall be set for fast response and for the A-weighting network.

5.2 The meter shall be observed while the vehicle is accelerating or decelerating. The highest sound level obtained for each run shall be recorded, ignoring unrelated peaks due to extraneous ambient noises.

5.3 At least six measurements shall be made for each side of the vehicle. Sufficient measurements shall be made until at least four readings from each side are within 2 dB of each other. The highest and lowest readings shall be discarded; the sound level for each side shall be the average of the four, which are within 2 dB of each other. The sound level reported shall be for that side of the vehicle having the highest sound level.

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

5.5 Wind speed at the test site during tests shall be less the 19 km/h (12 mph).

6. GENERAL COMMENTS

6.1 Technically competent personnel should select equipment, and the tests should be conducted only by trained and experienced persons familiar with the current techniques of sound measurement.

6.2 While making sound level measurements, not more than one person other than the rider and the observer reading the meter shall be within 15.2 m (50 ft) of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

6.3 The test rider should be fully conversant with and qualified to ride the machine under test and be familiar with the test procedure.

6.4 Proper use of all test instrumentation 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. Specific items to be considered are:

6.4.1 The type of microphone, its directional response characteristics, and its orientation relative to the ground plane and source of noise.

6.4.2 The effects of ambient weather conditions on the performance of all instruments (for example, temperature, humidity, and barometric pressure).

6.4.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems.

6.4.4 Proper acoustical calibration procedure, to include the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

6.5 Vehicles used for tests must not be operated in a manner such that the break-in procedure specified by the manufacturer is violated.

7. REFERENCES

Suggested reference material is as follows:

7.1 ANSI S1.1-1960, Acoustical Terminology.

7.2 ANSI S1.2-1962, Physical Measurement of Sound.

7.3 ANSI S1.4-1971, Specification for Sound Level Meters.

7.4 ANSI S1.13-1971, Method of Measurement of Sound Pressure Levels.

7.5 SAE J184, Qualifying a Sound Data Aquisition System.

7.6 SAE J331, Sound Levels for Motorcycles.

MEASUREMENT OF NOISE EMITTED BY VEHICLES[15/]

1. SCOPE

This ISO Recommendation describes methods of determining the noise emitted by motor vehicles, these being intended to meet the requirements of simplicity as far as is consistent with reproducibility of results and realism in the operating conditions of the vehicle.

2. GENERAL REQUIREMENTS

2.1 Test conditions

This ISO Recommendation is based primarily on a test with vehicles in motion, the ISO reference test. It is generally recognized to be of primary importance that the measurements should relate to normal town driving conditions, thus including transmission noise etc. Measurements should also relate to vehicle conditions which give the highest noise level consistent with normal driving and which lead to reproducible noise emission. Therefore, an acceleration test at full throttle from a stated running condition is specified.

Recognizing, however, that different practices already exist, specifications of two other methods used are also given in the Appendix. These relate to:

(a) a test with stationary vehicles (see Appendix A1) and

(b) a test with vehicles in motion, under vehicle conditions which (in the case of certain vehicles) are different from those in the ISO reference test (see Appendix A2).

When either of these tests is used, the relation between the results and those obtained by the ISO reference test should be established for typical examples of the model concerned.

2.2 Test site

The test methods prescribed call for an acoustical environment which can only be obtained in an extensive open space. Such conditions can usually be provided

for type-approval measurements of vehicles,

for measurements at the manufacturing stage, and

for measurements at official testing stations.

It is desirable that spot checking of vehicles on the road should be made in a similar acoustical environment. If measurements have to be carried out on the road in an acoustical environment which does not fulfil the requirements stated in this ISO Recommendation, it should be recognized that the results obtained may deviate appreciably from the results obtained using the specified conditions.

2.3 Interpretation of results

The results obtained by the methods specified give an objective measure of the noise emitted under the prescribed conditions of test. Owing, however, to the fact that the subjective appraisal of the annoyance or noisiness of different classes of motor vehicles is not simply related to the indications of a sound level meter, it is recognized that the correct interpretation of results of the measurements in this ISO Recommendation may require different limits to be set for the corresponding annoyance of different classes of vehicles.

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3. MEASUREMENT EQUIPMENT

A high quality sound level meter should be used. The weighting network and meter time constant employed should be curve " A " and " fast response " respectively, as specified in Recommendation No. 123 of the International Electrotechnical Commission for Sound Level Meters. A detailed technical description of the instrument used should be supplied.

NOTES

1. The sound level measured using sound level meters having the microphone close to the instrument case may depend on the orientation of the instrument with respect to the sound source, as well as on the position of the observer making the measurement. The instructions given by the manufacturer concerning the orientation of the sound level meter with respect to the sound source and the observer should therefore be carefully followed.
2. If a wind shield is used for the microphone, it should be remembered that this may have an influence on the sensitivity of the sound level meter.
3. To ensure accurate measurements, it is recommended that before each series of measurements the amplification of the sound level meter be checked, using a standard noise source and adjusting as necessary.
4. It is recommended that the sound level meter and the standard noise source be calibrated periodically at a laboratory equipped with the necessary facilities for free-field calibration.

Any peak which is obviously out of character with the general sound level being read should be ignored.

4. ACOUSTICAL ENVIRONMENT

The test site should be such that hemispherical divergence exists to within $\pm$ 1 dB.

NOTE.—A suitable test site, which could be considered ideal for the purpose of the measurements, would consist of an open space of some 50 m radius, of which the central 20 m, for example, would consist of concrete, asphalt or similar hard material.

In practice, departure from the so-called " ideal " conditions arises from four main causes:

(*a*) sound absorption by the surface of the ground;

(*b*) reflections from objects, such as buildings, and trees, or from persons;

(*c*) ground which is not level or of uniform slope over a sufficient area;

(*d*) wind.

It is impracticable to specify in detail the effect produced by each of these influences. It is considered important, however, that the surface of the ground within the measurement area be free from powdery snow, long grass, loose soil or ashes.

To minimise the effect of reflections, it is further recommended that the sum of the angles subtended at the position of the test vehicle by surrounding buildings within 50 m radius should not exceed 90° and that there be no substantial obstructions within a radius of 25 m from the vehicle.

Acoustical focussing effects and sites between parallel walls should be avoided.

Wherever possible, the level of ambient noise (including wind noise and—for stationary tests—roller stand and tyre noise) should be such that the reading produced on the meter is at least 10 dB below that produced by the test vehicle. In other cases, the prevailing noise level should be stated in terms of the reading of the meter.

NOTE.—Care should be taken that gusts of wind do not distort the results of the measurements.

The presence of bystanders may have an appreciable influence on the meter reading, if such persons are in the vicinity of the vehicle or the microphone. No person other than the observer reading the meter should therefore remain in the neighbourhood of the vehicle or the microphone.

NOTE.—Suitable conditions exist, if bystanders are at a distance from the vehicle which is at least twice the distance from vehicle to microphone.

5. MEASUREMENTS WITH VEHICLES IN MOTION

5.1 Testing ground

The testing ground should be substantially level, and its surface texture such that it does not cause excessive tyre noise.

5.2 Measuring positions

The distance from the measuring positions to the reference line *CC* (Fig. 1) on the road should be 7.5 m. The path of the centre line of the vehicle should follow as closely as possible the line *CC*.

The microphone should be located 1.2 m above the ground level.

5.3 Number of measurements

At least two measurements should be made on each side of the vehicle as it passes the measuring positions.

NOTE.—It is recommended that preliminary measurements be made for the purpose of adjustment. Such preliminary measurements need not be included in the final result.

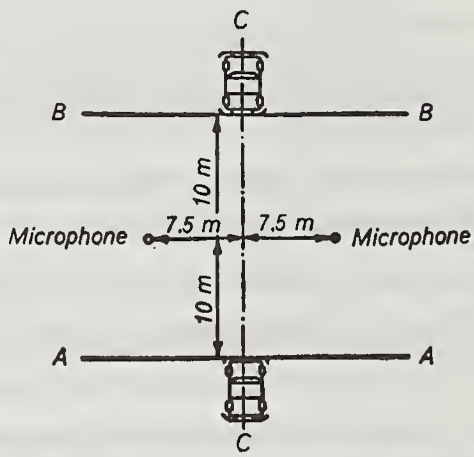


Fig. 1. — **Measuring positions for measurement with vehicles in motion**

5.4 Test procedure

5.4.1 *General conditions*

The vehicle approaches the line *AA* in the appropriate conditions specified below:

When the front of the vehicle reaches the position, in relation to the microphone, shown as *AA* in Figure 1, the throttle is fully opened as rapidly as practicable and held there until the rear of the vehicle reaches position *BB* in Figure 1, when the throttle is closed as rapidly as possible.

Trailers, including the trailer portion of articulated vehicles, are ignored when considering the crossing of line *BB*.

NOTE.—If the vehicle is specially constructed with equipment (such as concrete mixers, compressors, pumps, etc.), which is used whilst the vehicle is in normal service on the road, this equipment should also be operating during the test.

5.4.2 *Particular conditions*

5.4.2.1 VEHICLE WITH NO GEAR-BOX. The vehicle should approach the line *AA* at a steady speed corresponding

either to an engine speed of three quarters of the speed at which the engine develops its maximum power,

or to three quarters of the maximum engine speed permitted by the governor,

or to 50 km/h,

whichever is the lowest.

5.4.2.2 VEHICLE WITH A MANUALLY OPERATED GEAR-BOX. If the vehicle is fitted with a two-, three-, or four-speed gear box, the second gear should be used. If the vehicle has more than four speeds, the third gear should be used. Auxiliary step-up ratios (" overdrive ") should not be engaged. If the vehicle is fitted with an auxiliary reduction gear box, this should be used with the drive allowing the highest vehicle speed.

The vehicle should approach the line *AA* at a steady speed corresponding

either to an engine speed of three quarters of the speed at which the engine develops its maximum power,

or to three quarters of the engine speed permitted by the governor,

or to 50 km/h,

whichever is the lowest.

5.4.2.3 VEHICLE WITH AN AUTOMATIC GEAR-BOX. The vehicle should approach the line *AA* at a steady speed of 50 km/h or at three quarters of its maximum speed, whichever is the lower. Where alternative forward drive positions are available, that position which results in the highest mean acceleration of the vehicle between lines *AA* and *BB* should be selected.

The selector position which is used only for engine braking, parking or similar slow manœuvres of the vehicle should be excluded.

5.4.2.4 AGRICULTURAL TRACTORS, SELF-PROPELLED AGRICULTURAL MACHINES AND MOTOR CULTIVATORS. The vehicle should approach the line *AA* at a steady speed of three quarters of the maximum speed which can be achieved, using the gear-box ratio which gives the highest road speed.

5.5 Statement of results

All readings taken on the sound level meter should be stated in the report.

The basis of horsepower rating, if appropriate, should be stated in the report.

The state of loading of the vehicle should also be specified in the report.

A1. MEASUREMENTS WITH STATIONARY VEHICLES

A1.1 Measuring positions

Measurements are made in each of the four main directions at a distance of 7.0 m from the nearest surface of the vehicle. The actual positions used for the measurements are shown in Figure 2. If measurements are required in more than the four measuring positions shown in Figure 2, they should be taken from chosen positions on the circles shown — i.e. the circles with radius 7.0 m.

The microphone should be located 1.2 m above the ground level.

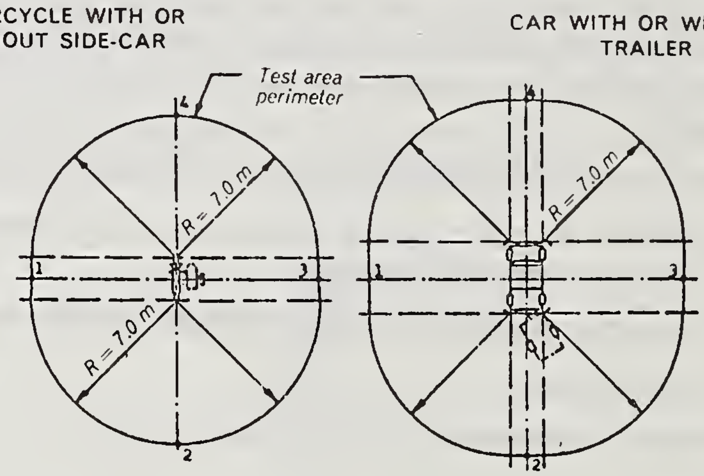


Fig. 2. — Measuring positions for measurement with stationary vehicles

A1.2 Number of measurements

At least two measurements should be made in each measuring position.

A1.3 Vehicle conditions

The engine of the vehicle without a speed governor should be run at three quarters of the number of revolutions per minute at which, according to the manufacturer, it develops its maximum power. The engine speed, expressed in revolutions per minute, is measured by means of an independent instrument, e.g. by the use of free-running rollers and a tachometer. A governed engine should be run at maximum speed.

The engine should be brought to its usual working temperature before measurements are carried out.

A1.4 Statement of results

All the sound level readings observed in each measuring position should be stated in the report.

A2. MEASUREMENTS WITH VEHICLES IN MOTION (MODIFIED METHOD)

A 2.1 Testing ground

The testing ground should be substantially level, and its surface texture such that it does not cause excessive tyre noise.

A 2.2 Measuring positions

The distance from the measuring positions to the reference line *CC* (Fig. 1) on the road should be 7.5 m. The path of the centre line of the vehicle should follow as closely as possible the line *CC*.

The microphone should be located 1.2 m above the ground level.

A 2.3 Number of measurements

At least two measurements should be made on each side of the vehicle as it passes the measuring positions.

NOTE.—It is recommended that preliminary measurements be made for the purpose of adjustment. Such preliminary measurements need not be included in the final result.

A 2.4 Test procedure

A2.4.1 *General conditions*

The vehicle approaches the line *AA* in the appropriate conditions specified below:

When the front of the vehicle reaches the position, in relation to the microphone, shown as *AA* in Figure 1, the throttle is fully opened as rapidly as practicable and held there until the rear of the vehicle reaches position *BB* in Figure 1, when the throttle is closed as rapidly as possible.

Trailers, including the trailer portion of articulated vehicles, are ignored when considering the crossing of line *BB*.

NOTE.—If the vehicle is specially constructed with equipment (such as concrete mixers, compressors, pumps, etc.), which is used whilst the vehicle is in normal service on the road, this equipment should also be operating during the test.

A2.4.2 *Particular conditions*

Vehicles should be driven in such a manner as to comply with either of the following conditions:

A2.4.2.1 VEHICLE WITH A MANUALLY OPERATED GEAR BOX, WITH OR WITHOUT AUTOMATIC CLUTCH. The vehicle should approach the line *AA* (Fig. 1) at a steady speed corresponding to three quarters of the revolutions per minute at which the engine (according to the manufacturer) develops its maximum power. The gear ratio should be chosen such that the road speed most closely approaches 50 km/h at this engine speed. However, if the vehicle has more than three forward gears, the first gear should not be used.

A2.4.2.2 VEHICLE WITH AN AUTOMATIC GEAR BOX. The vehicle should approach the line *AA* at a steady speed of 50 km/h or at three quarters of its maximum speed, whichever is the lower. Where alternative forward drive positions are available, the position which results in the highest sound level of the vehicle should be selected.

The selector position which is used only for engine braking, parking or similar slow manœuvres of the vehicle should be excluded.

A 2.5 Statement of results

All readings taken on the sound level meter should be stated in the report.

The basis of horsepower rating, if appropriate, should be stated in the report.

The state of loading of the vehicle should also be specified in the report.

U.S.D.A. PROPOSED

SOUND LEVEL STANDARD AND TEST PROCEDURE FOR MOTORCYCLES

1. INTRODUCTION

This standard describes sound level limits for motorcycles used on National Forest lands. This test procedure establishes methods and describes the test environment and instrumentation for determining these sound levels.

2. SOUND LEVEL LIMITS

2.1 All motorcycles operated on National Forest lands must be equipped at all times with an exhaust muffler equivalent in performance to at least the manufacturer's original equipment. When a motorcycle has been sold without an exhaust muffler, silencing equipment must be installed, including but not limited to an exhaust muffler, so as the total sound level, measured by the method described herein, does not exceed 86 dBA.

2.2 All motorcycles operated on National Forest lands, which are sold new after January 1, 1975, must not produce more than 82 dBA when measured by the method described herein.

2.3 All motorcycles operated on National Forest lands, which are sold new after January 1, 1980, must not produce more than 75 dBA, when measured by the method described herein.

3. INSTRUMENTATION

The following instrumentation shall be used for the measurement required:

3.1 A sound level meter which meets the requirements of American National Standards Institute S1.4-1971, General Purpose Sound Level Meters.

3.1.1 Alternately, a microphone/magnetic tape recorder/indicating meter system whose overall response meets SAE Recommended Practice J184, "Qualifying a Sound Data Acquisition System".

3.2 A sound level calibrator (see paragraph 5.5).

3.3 A calibrated windscreen or nose cone (see paragraph 5.4).

4. PROCEDURE

4.1 TEST SITE - A test site suitable for the purpose of measurements shall consist of a flat open space free of large reflecting surfaces such as signboards, buildings, or hillsides located within 50 ft. of either the vehicle or the microphone. Other site limitations shall be as shown in figure 1.

4.1.1 The surface of the ground within the measurement area shall be paved. If this is not possible, then at least the vehicle path shall be paved, or well-packed earth or gravel.

4.1.2 Because bystanders may have an appreciable influence on meter response when they are in the vicinity of the vehicle or the microphone, not more than one person other than the observer reading the meter shall be within 50 ft of the vehicle or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

4.1.3 The ambient sound level (including wind effects) due to sources other than the vehicle being measured shall be at least 10 dBA lower than the level of the tested vehicle.

4.1.4 The path of vehicle travel shall be relatively smooth.

4.1.5 The microphone shall be located 50 ft from the centerline of the vehicle path at a height of 4 ft above the ground plane.

4.1.6 An acceleration point (point A) shall be established on the vehicle path 25 ft before a line through the microphone and normal to the vehicle path.

4.2 VEHICLE OPERATIONS

4.2.1 The vehicle shall proceed along the test path at a constant approach speed. The vehicle engine shall be run at 60% of the engine speed at maximum rated net horsepower. The vehicle tachometer shall be used to determine this speed. If the vehicle is not equipped with a tachometer, then the appropriate vehicle speed must be calculated by the following formula:

$$\text{Approach vehicle speed} = \left[\frac{(0.6)\text{X}(\text{maximum hp engine speed})}{\text{overall gear ratio}}\right] \text{X} \left[\text{rear wheel measured circumference, ft}\right] \text{X} \left[0.0114\right]$$

The lowest gear which does not permit maximum rated net horsepower engine rpm to be developed within 50 ft of point A shall be used. When the front of the vehicle reaches the acceleration point, the throttle shall be opened wide, and maintained until the front of the vehicle is 25 ft beyond the microphone.

4.3 MEASUREMENTS

4.3.1 The meter shall be set for "fast" response and for the A-weighted network. If the meter is equipped with "hold" it may be used, provided the response time is identical to that used on "fast." ("Impulse" may <u>not</u> be used.)

4.3.2 The meter shall be observed while the vehicle is accelerating. The applicable reading shall be the highest sound level obtained for the run, ignoring unrelated peaks due to extraneous ambient noises. Sufficient preliminary runs to familiarize the driver and to stabilize the engine operating conditions shall be made before measurements begin. Immediately after the preliminary runs, at least two measurements shall be made for each side of the vehicle. All of the values shall be recorded.

4.3.3 The sound level for each side of the vehicle shall be the average of the two highest readings which are within 2 db of each other. The sound level reported shall be that of the louder side of the vehicle.

5. GENERAL COMMENTS

5.1 It is strongly recommended that technically trained personnel select equipment and that tests be conducted only by qualified persons trained in the current techniques of sound measurement.

5.2 An additional 3 dBA allowance over the sound level limit is recommended to provide for variations in test site, vehicle operation, temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles.

5.3 Instrument manufacturer's specification for orientation of the microphone relative to the source of sound and the location of the observer relative to the meter should be adhered to.

5.4 When a windscreen is required, a previously calibrated windscreen should be used. It is recommended that measurements be made only when wind velocity is below 12 mph.

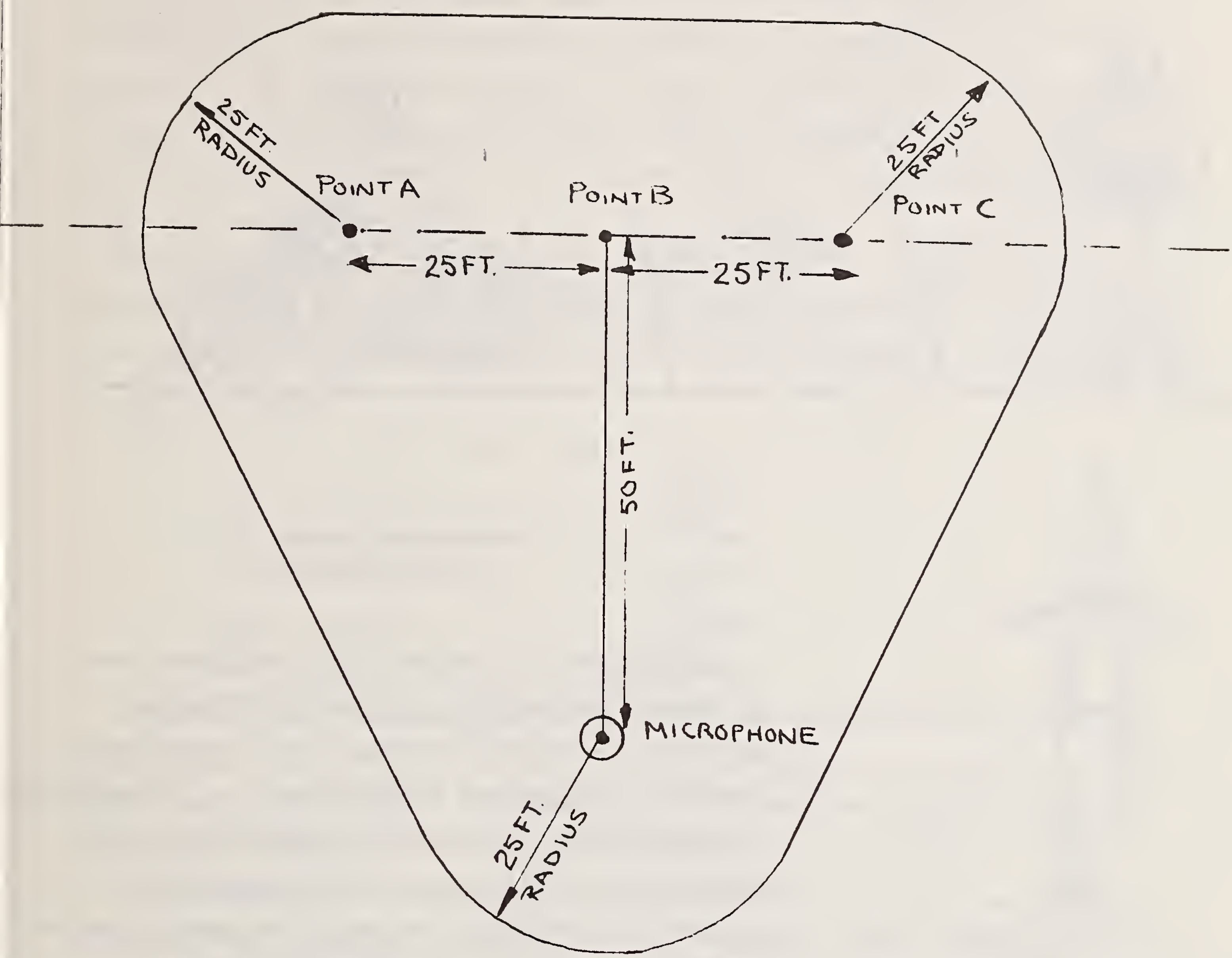
5.5 Instrument manufacturer's recommended calibration practice should be followed. Field calibration should be made immediately before and after each test sequence. Either an external calibrator or internal calibration means is acceptable for field use, provided that external calibration is accomplished immediately before or after field use.

6. REFERENCE MATERIAL

Suggested reference material is as follows:

ANSI S1.1-1960, Acoustical Terminology
ANSI S1.2-1962, Physical Measurement of Sound
ANSI S1.4-1971, Standard Specification for Sound Level Meters
SAE J184 - Qualifying a Sound Data Acquisition System

(Applications for copies of these documents should be addressed to American National Standards Institute, 1430 Broadway, New York, N. Y. 10018, and the Society of Automotive Engineers, 2 Pennsylvania Plaza, New York, N.Y. 10001.)



COURSE REQUIREMENTS

Course flat between Points A & B.

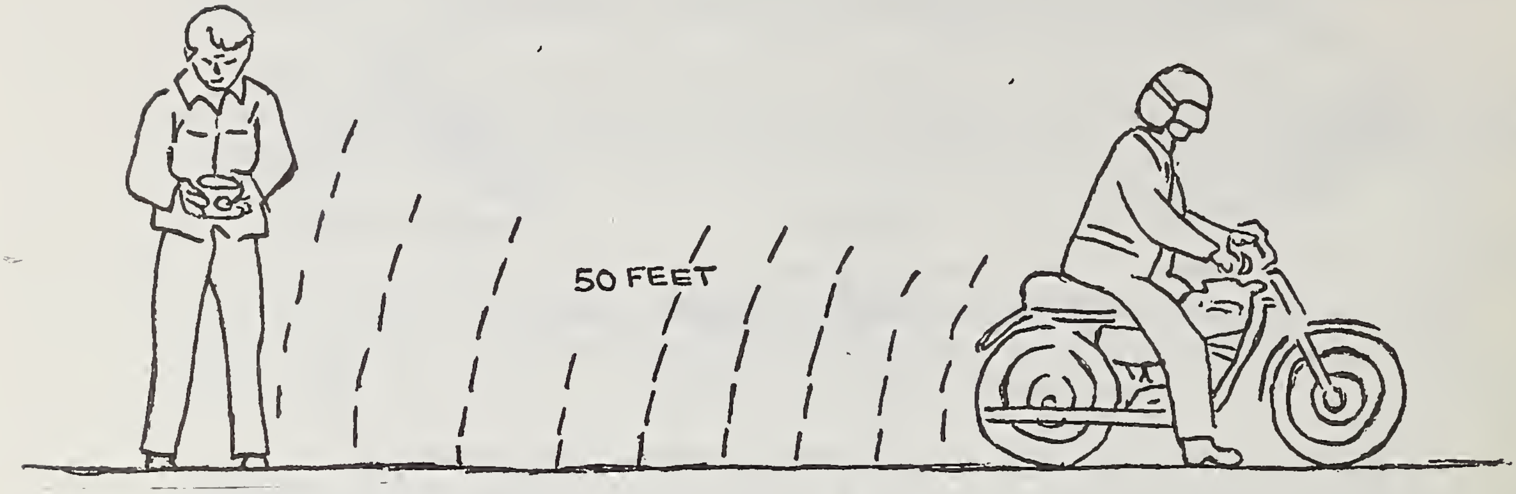
No obstructions within boundary shown.

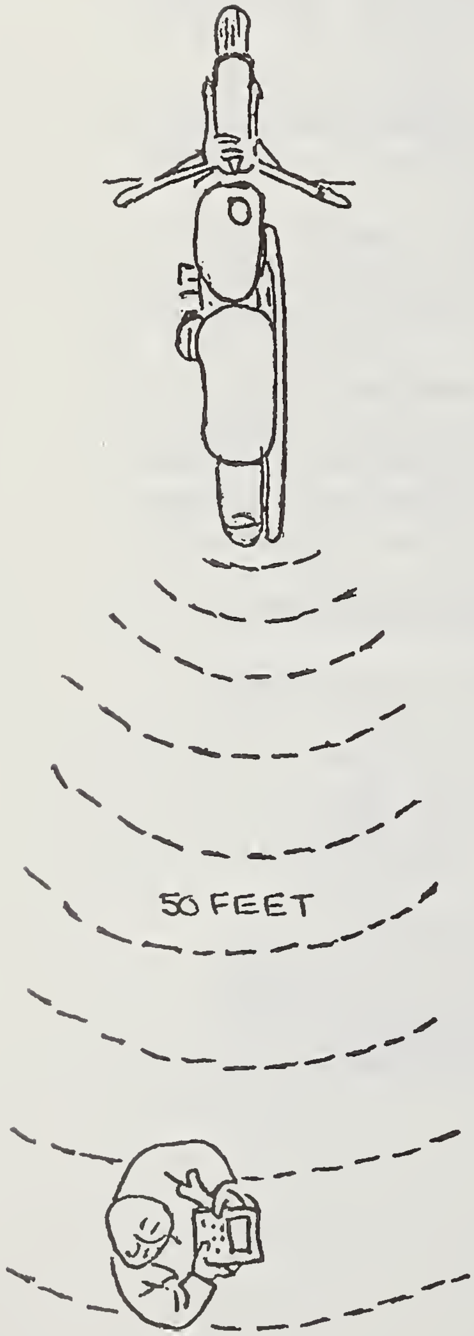
No obstructions higher than 3 ft within 50 ft of Points A, B, & C, or Microphone

Ground cover within the boundary shown shall not be more than six inches high.

Figure 1

NOISE MEASUREMENT PROCEDURE USED FOR QUALIFICATION IN AMERICAN MOTORCYCLE ASSOCIATION SANCTIONED OFF-ROAD COMPETITION





RECOMMENDED NOISE TESTING METHOD

During the FIM spring, 1972, congress held in Geneva, Switzerland, the world governing body for the sport of motorcycling adopted noise standards and testing methods based on proposals by the delegates of the American federation. After experiencing difficulties with various methods designed for technical accuracy and sophistication, the FIM turned to the American Motorcycle Association for suggestions with the hope that a world-wide noise abatement program could be established, based on a practical, easily-administered method of noise testing.

The FIM method provides that all machines under examination be measured at a distance of 50 feet (15.2m). They should be running in neutral with the noise level reading taken at a pre-determined motor speed, depending upon the size of the motor-cycle.

A hand-held meter, such as that available from the AMA, should be held about 4 feet (1.2m) from the ground (a comfortable posture with the elbows bent) with the microphone pointing at a right angle to the motorcycle. The individual holding the meter, preferably the referee in charge or someone appointed by him, takes the reading of each motorcycle and reports it to a clerk who should record it beside the contestant's number on a entry list.

With the motorcycle started and running in neutral, the motor is accelerated to a certain rpm and held there just long enough for the reading to be taken. Care should be taken not to over-rev the motor or to hold it at speed too long.

Below are the reading speeds established by the FIM:

50cc to 75cc 6000rpm
100cc to 125cc 5500rpm
175cc to 250cc 5000rpm
350cc to 500cc 4500rpm
over 500cc 4000rpm

Note that these recommendations are based on traditional FIM class designations. If a motor size falls between categories, it should be moved to the next larger class. For example, a 150cc machine should be measured at 5000 rpm, falling into the class of motorcycles up to 250cc.

If the motorcycle has no tachometer, the testing crew may want to use a counter which attaches to the electrical system, a method suggested by the FIM. If no such device is available, the motor speed should be estimated at 2/3 maximum safe revolutions.

No motorcycle, tested at the motor speed designated for its motor class, may exceed 92 decibels (92 dB(a)) and be * legal for AMA amateur competition or professional moto-cross.

Common sense should be followed in administering this test. For example, only the motorcycle being tested should be running. An open area should be chosen so that the contestant will not be jeopardized by noise echoing from walls or other large objects.

* This level is now set at 90 dBA.

This method is designed for its simplicity. More sophisticated and accurate methods are available but they are more complicated, difficult and expensive to administer. Furthermore, with the more complicated methods, the individual being tested can usually find more ways to manipulate the noise level of his machine and control the results to his benefit.

For those interested in improving the sport of motorcycling by reducing offensive noise, this simple method, administered in a spirit of cooperation by official and contestant alike, is a most convenient and effective technique.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report reviews existing motorcycle noise measurement procedures with regard to their usefulness in the regulation of motorcycle noise as well as the availability, extent and applicability of existing data. On the basis of this review, probable or potential measurement difficulties are identified that could hinder the promulgation and/or enforcement of future EPA regulations to control the noise emission from motorcycles.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Acoustics (sound); measurement methodology; motorcycle; noise emisson standard; noise measurement.

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