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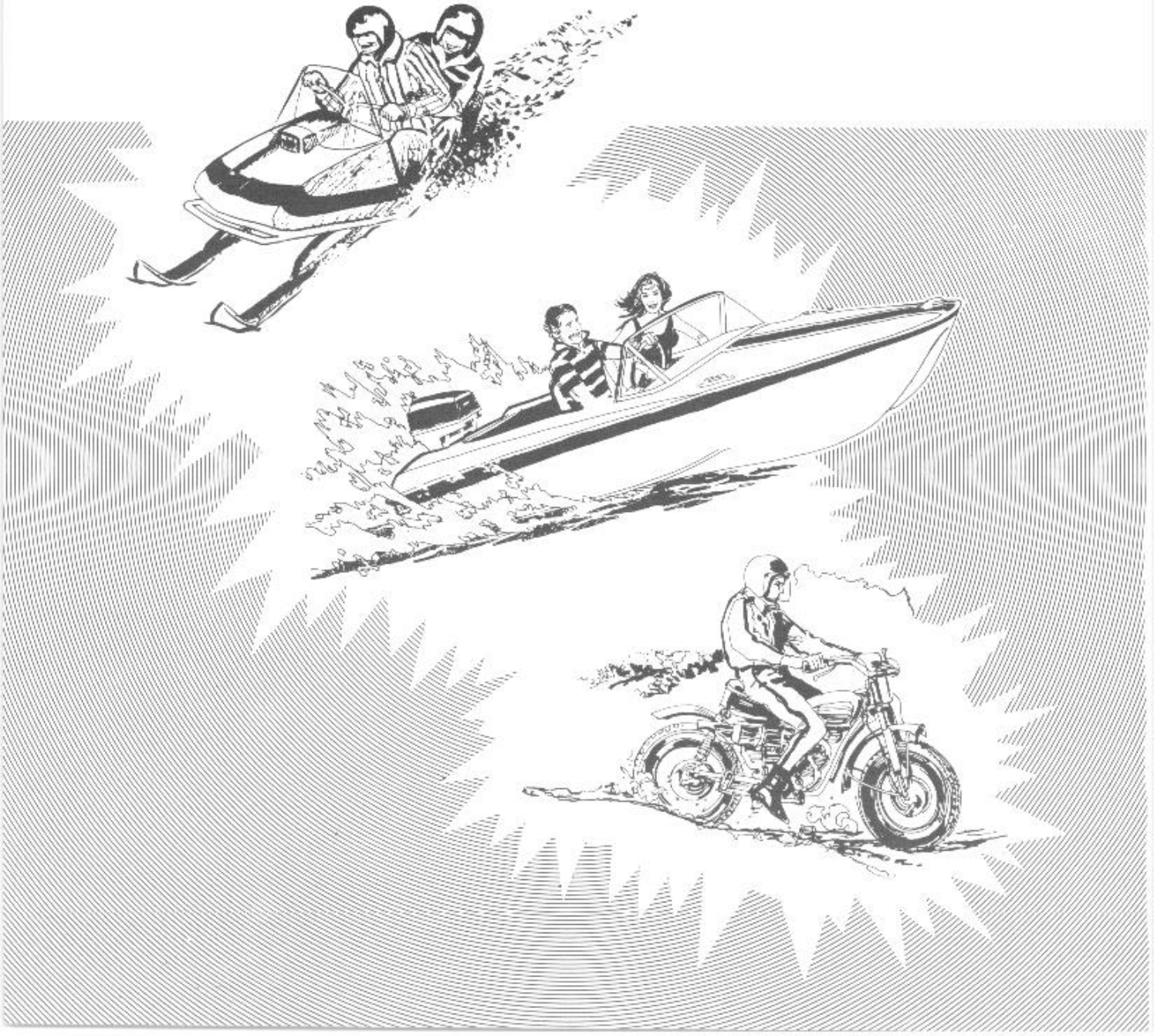

Off-Road Vehicle(ORV) Sound-Level Regulations and Their Enforcement

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ED&T Project No. 9227
Impact of ORV's on Forest Values

Forest Service
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INTRODUCTION

This Project Record presents information on off-road vehicle (ORV) sound impacts and sound-level regulation. This information is for use by National Forest officers who prepare environmental impact statements and vehicle monitoring and travel plans. *As used herein, the term "ORV" includes motorcycles, dune buggies, four-wheel drive and all-terrain vehicles (ATV's), snowmobiles, and motorboats.* These constitute a group of conveyances that can have the same general principles of sound-level control and regulation applied to them. But, since they each have some unique factors, some aspects of their regulation must be dealt with by specific vehicle type.

The degree of sound impact generated by motorized recreationists varies with the type of ORV in use, its sound-control equipment, any modifications made to the factory configuration of the ORV, the characteristics of the site where it is being used, and characteristics of listeners to the sound. To assess ORV environmental impact, or plan for ORV travel, a land manager must have a fairly detailed knowledge of the acoustic characteristics of the ORV. Since these characteristics are many times changed by owner modifications to the vehicle, a manager can ensure that the ORV, as a sound source, does not exceed a given level only by issuing appropriate regulations and enforcing them.

Authority to control ORV sound on National Forests is contained in 36 CFR 261.13(b). This prohibits the operation of " . . . any vehicle on Forest development, State, or county roads . . . in violation of any applicable noise emission standard established by any Federal or State agency." The CFR further states that in case such regulations conflict, the strictest should be enforced.

This Project Record is a companion document to a previous San Dimas Equipment Development Center (SDEDC) report (12) that deals with determining the acceptability of recreation impacts, provides some basics on the physics of sound, and details "SPreAD" (System for the Prediction of Acoustic Detectability). The latter is an in-depth method for *calculating* (a) sound energy losses that occur as sound travels through the air and (b) the estimated acoustic impact of a sound source (such as an ORV) at a distant listener location. Another SDEDC report (13) deals specifically with the probable impact of snowmobile sound on nonsnowmobiling recreationists.

The first of the three main sections of this Project Record, "Vehicle Sound Impacts," describes the nature of the acoustic impact that can be expected in a given area as a result of ORV operation. The following section, "Regulating Vehicles" (of particular interest to authors of ORV travel plans), presents suggested sound-limit regulations. The next, "Suggested Enforcement Techniques," focuses on the enforcement of the regulations. Finally, test methods to determine whether or not ORV's are in compliance with the regulations are given in the appendixes, which also explain how off-road motorcycles and pleasure motorboats can be classified for purposes of regulation.

VEHICLE SOUND IMPACTS

Nature of the Problem

There are two major viewpoints for studying the nature of a vehicle's sound—setting (or environment) and health (3). Figure 1 presents an overview of these viewpoints and possible impacts on recreation.

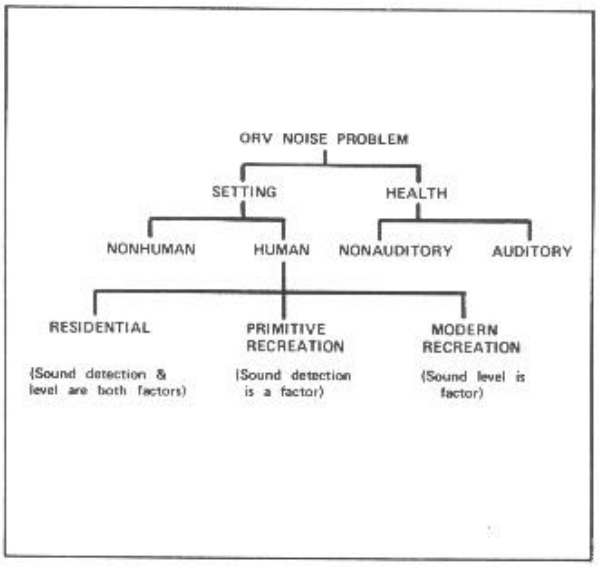

Figure 1. Overview of ORV noise impact on recreation opportunities.

Settings include those environments where humans are not considered and those where they are. Those settings in which a person's presence is important can be subdivided into (a) residential (urban, suburban, and rural), where the presence of ORV's may be objectionable and the mere detection of their noise is a factor, (b) primitive recreation areas, with the same human elements at work, and (c) modern recreation areas, where the presence of ORV's is not objectionable—unless they create "excessive" noise.

The most serious effect of these impacts is likely to be in a conflict between vehicle operators and other recreationists. For example, dissatisfaction with the

environment (setting) might be expressed by hikers who acoustically perceive that off-road motorcycles are operating in "their" area.

Various Settings

Nonhuman. There is a great deal of speculation that noise from ORV's (particularly from snowmobiles) causes serious impact on some species of wildlife. However, only a few well-controlled studies on this subject have been carried out, and these have generally been inconclusive (7). Most authorities agree that the effects of ORV noise on wildlife are indistinguishable from the effects that the mere presence of humans has on the animals. That is, just the fact that people are present (and not the noise they make) is likely to cause distress to animals. Work in northern Canada has shown that waterfowl react to low-flying aircraft in the same manner that they react to low-flying raptors (6). Deer and rabbits have been shown to be quite adaptable to the noise of snowmobiles (1).

Most researchers agree that any effects of noise on animals are limited to the higher animals—mammals, birds, and (possibly) the higher reptiles. Although there is some speculation that ORV noise might affect the habitat of insects that use acoustic communication, there appears to be no support for this proposition in the literature. Since insects have small hearing organs, they use mostly high frequencies for communication. These frequencies are well above those contained in the total noise output of ORV's (2).

There are no known or suspected effects of ORV noise on plant life. Although some have asserted that noise and vibrations from ORV's cause the destruction of unique land forms and sites of archaeological interest, the supporting research is of questionable validity (3).

Human. Only the nonhealth effects of ORV noise are considered here. The major of these is annoyance. This can range, depending on the affected individual, from a mild feeling of being imposed upon to a feeling of unreasoning rage directed at the ORV operator specifically and the land manager in general. This conflict between recreationists is likely to be the most significant ORV noise impact. [1/] A comprehensive method of land use planning, designed to minimize this noise impact, is available (12). Under some circumstances the noise can cause some impairment of health; these effects are dealt with in the discussion of nonauditory health aspects.

The only aspects of a residential setting that directly concern the Forest Service are those situations in which Forest Service employees or their dependents are operating ORV's in work camps or Government housing areas, or when ORV's on National Forests are operating in areas near housing developments. Under these circumstances, the mere knowledge on the part of a listener that an ORV is operating in the area is likely to lead to significant annoyance in a certain percentage of the population. A small portion of the listeners in this setting will be motivated to complain to local authorities if the noise level reaching them were loud enough for detection and identification of the source, but not so loud as to cause interference with their speech communication. However, if speech interference, or interference with television or radio listening is caused, a much larger percentage may be moved to complain.

In primitive recreation areas, a much lower noise level is likely to give rise to considerable annoyance in any given listener. Most people who go to the woods go to escape the hubbub of civilization. Even people who consider the noise of an ORV near their home or workplace inevitable might not accept this noise after spending considerable time, effort, and money to get away from it. However, ORV recreationists share the same feelings about the outdoors that nonmotorized recreationists do, and some of their best ORV recreation experiences are in primitive areas. [2/]

Conflicts thus seem inevitable; these conflicts are likely to be the greatest impact of ORV operation. In a primitive recreation area, these conflicts can be minimized by separating areas used by ORV's from areas used by those susceptable to ORV noise. SPreAD (12) provides a method for predicting the necessary separation of use areas. Limiting the sound output of each individual ORV used in an area reduces the separation required between use areas. Ways of limiting the noise from each ORV are dealt with under "Regulating ORV Noise" in this Project Record.

In modern recreation areas, where the nonmotorized recreationist probably knows that the presence of ORV's is inevitable, the sound level (loudness) of the ORV becomes a definite factor in the annoyance felt by the listener. To experienced Forest Service technicians, a dune buggy with a sound level of 85 dBA at 50 feet under wide-open throttle acceleration is considered acceptable, and they feel that it is also considered acceptable by most visitors to a typical recreation area (10). Thus, in an area where

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[1/] Fidell, Sanford. 1980. Personal communication. Bolt Beranck and Newman, Inc., Cambridge, Mass.

[2/] Nichols, Garrel. 1980. Land use consultant speaking at Va. Recr. Trailbike Wrkshp. Mtrcycl. Indus. Council, Newport Beach, Calif.

the presence of ORV's is not objectionable but the noise may be, 85 dBA at 50 feet has been shown to be an acceptable level. (This level is roughly equivalent to the 99-dBA limit, by the appropriate test method, given in table 1 under "Regulating ORV Noise.")

Another impact to be considered is that of ORV noise on historical sites and designated Native American spiritual grounds. The psychological impact of the mere detection of ORV noise on such sensitive areas as holy grounds and cemeteries, or sites of particular historical or archaelogical interest, should be considered. This impact can be eliminated *only* by the exclusion of ORV's from these areas. The distance that ORV operations must be removed from such sites can be determined by SPreAD. [3/]

Health Effects

Nonauditory. Nonauditory noise effects are difficult to define. There is no question that noise causes unpleasant physical reactions. However, medical authorities are divided as to whether or not these noise-caused reactions are due to annoyance and resentment at the noise source (the generalized stress syndrome), or a direct result of the noise itself. The weight of the literature favors the annoyance and resentment view.

Cardiovascular, digestive, and neurohumoral disturbances have all been attributed to noise of a lower overall level than that necessary to cause hearing damage—particularly when the noise gives rise to the "startle response." Since the noise of an ORV is not startling, unpleasant, or distressful to the operator, the nonauditory effects of ORV noise are probably confined to bystanders, who (in most cases) are unwilling spectators to the operation of the ORV. The startle response is unlikely in a primitive recreation situation, as it is unlikely that any ORV can "sneak up" on a nonmotorized recreationist (15).

Sleep interference is one of the most often mentioned nonauditory ORV noise health problems. That one need not be fully awakened by a noise to experience serious sleep disruption has amply been shown (8). However, in most forest recreation situations, ORV's are not usually operated at night, so this impact is probably of minor importance.

Auditory. Hearing damage is a function of both the level of the sound reaching the ear and the amount of time that the listener is exposed to this level. In most cases, the sound reaching a bystander will not be great enough to cause any hearing damage, particularly in a forest situation.

The sound of ORV's of all classes can be loud enough to cause permanent hearing damage to both operators and passengers if the engine and exhaust are not properly silenced. Snowmobiles have been the most thoroughly studied. Measurements made of snowmobile sound levels at the operator's ear indicate that, for some pre-1976 snowmobiles under some operating conditions, dangerous levels are achieved. This conclusion is supported by measurements made of the hearing of snowmobile operators (9). Current snowmobiles and motorcycles are much quieter than previous models and thus their auditory impacts are correspondingly smaller.

If, as a condition of use on National Forests, ORV's are required to meet the sound limits suggested in the section that follows, typical recreational exposures will be well below the level likely to cause hearing damage. For Forest Service employees, required to ride ORV's for long periods of time, hearing protectors are suggested (11).

Other noise impact issues involve the ability of (a) ORV operators and passengers to communicate verbally and (b) operators to detect acoustically any mechanical problems with the ORV's major components. As to the latter, there are many ORV operators who are under the mistaken impression that they can better monitor the operation of the ORV's engine, transmission, etc., if the vehicle is completely unmuffled. This is not so because, in most cases, if the exhaust sound is very loud (i.e., the ORV has no muffler) it will mask other mechanical sounds that may provide valuable information to the operator.

REGULATING VEHICLES

Benefits

The main benefit to be gained by regulating ORV noise is a reduction in the extent of noise impact. For example, reducing a motorcycle's operating sound by 6 dB reduces the area in which that motorcycle is detectable by 75 percent.

Experience shows that a small number of ORV owners mistakenly feel that removing mufflers from their vehicles improves vehicular performance. An even smaller group appears to enjoy operating as loud an ORV as they can get. These loud vehicles, some more than 12 dB louder than stock vehicles, result from modification of the stock exhaust system or from inappropriate use (e.g., use of a motocross racing motorcycle in a trail-riding situation). The worst of these vehicles impact more than ten times the area that properly silenced ORV's impact.

[3/] Harrison, Robin T. 1972-73. Data on file U.S. Dep. Agric. For. Serv., Eqpt. Dev. Ctr., San Dimas, Calif.

Approaches

For ORV's, the most successful regulatory programs have been those that embody the concepts of source control with numerical standards and strict enforcement of regulations (5, 14). This is the approach favored here; however, other approaches are available. When establishing appropriate regulatory levels, the feasibility of achieving such levels, the practicalities of enforcement, and the available technology must be considered.

Specifically for motorcycles, the U. S. Environmental Protection Agency (EPA) has preempted the Forest Service by setting a sound-*emission* standard (see 45 Fed. Reg. 252, 86694 et seq and 40 CFR 250, EPA Noise Emission Standards for Transportation Equipment, Motorcycles and Motorcycle Exhaust Systems). This preemption does not prevent the Forest Service from establishing *operational* standards. The preamble to the EPA regulations specifically reserves to "local authority" the ability to control: Manner of motorcycle operation, number of motorcycles that can be operated together, time of day and places where they may be operated, motorcycle licensing, and the environmental sound levels from motorcycles.

Source Control with Numerical Standards. There are two basic philosophies applicable to the numerical standards approach. One is control of the sound from an ORV; the other is control of the vehicle itself. The first philosophy is usually stated in language like: "No person shall operate an ORV under any circumstances in a manner to emit more than X dBA." This is the philosophy adopted in the EPA motorcycle regulations that were cited above. The second philosophy is generally stated thusly: "No person shall operate an ORV unless such ORV is equipped so that it does not emit noise in excess of Y dBA, when measured in accordance with the provisions of test method ABC."

Table 1 presents suggested values for "Y" dBA and procedures for "test method ABC" for various classes and subclasses of ORV's. The test procedures and sound levels have been selected so that the acoustic impact of each of the ORV classes and subclasses is roughly equal, but the differences in test methods necessitated by the differences in the nature of the vehicles themselves gives rise to different regulation levels. In other words, the actual noise impact from an ORV that a bystander perceives is a function of both the regulatory level and the test method used. Thus, the requirement that a snowmobile meet a 15-mph cruise-by at 50 ft of 73 dBA is roughly equivalent to the restriction in table 1 that a travel-type motorcycle meet a 95-dBA limit by the specified Society of Automotive Engineers (SAE) J1287 procedure.

Table 1. Suggested ORV maximum sound levels.

Vehicle class	Vehicle subclass	Test method	Sound limit (dBA)
Four-wheel drives, dune buggies, four- and six-wheel ATV's (including Honda's Odyssey)	N/A	½ max. hp engine speed @ 20 in. (Forest Service method)	99
Motorcycles and three-wheel ATV's	Small Large Competition	½ max. hp engine speed @ 20 in. (SAE J1287)	95 99 101
Snowmobiles	Mfg. on or after 6/30/76 Mfg. before 6/30/76	15-mph cruise-by @ 50 ft. (SAE J1161)	73[1] 77[1]
Motorboats	Sporting Fishing	Wide-open throttle. (SAE J34a)	86[1] 82[1]

[1] A 3-dBA tolerance should be allowed to account for differences in test sites, etc.

All ORV's legally sold in the United States (with the possible exception of inboard motorboats) must meet stringent sound-emission requirements. The limits listed in table 1 are a reflection of these requirements. All of the regulatory limits are, in essence, identical to those currently enforced by several States. Except for inboard motorboats, further reductions can probably not be achieved without seriously compromising the basic nature of the vehicles.

The previously cited EPA motorcycle sound-emission standards for transportation equipment are not effective until January 1, 1983. However, the regulatory levels embodied therein should probably be put into effect as soon as needed by a district, National Forest, or Region. The EPA has defined "small" motorcycles as those with 170 cc or less engine displacements and "large" motorcycles as those with displacements greater than 170 cc.

The sound limits suggested in table 1, as measured by SAE J1287, are roughly equivalent to these limits. (Perfect correlation between the EPA and SAE methods does not exist.) The EPA regulation, beginning with the 1986-model year, is lowered by 3 dB for small motorcycles and 4 dB for the large ones. At this time, how good the correlation between the EPA and SAE methods will be at these lower limits is uncertain. However, the SAE J1287 20-in test method should be used until 1986 by National Forest officers when enforcing sound-emission regulations.

The outboard motor, snowmobile, and motorcycle industries have been exemplary in reducing the noise of their products. However, a reduction of approximately 3 dB in the noise regulation for fishing boats can reasonably be required within 2 (or possibly 3) years after this regulation goes into effect on any National Forest. All current outboard motors, if unmodified, meet these strict requirements.

Comparison With Other Approaches. One alternative to the source control with numerical standards approach, already detailed, is a prohibition against operating (or even possessing) an ORV with any modified noise-control equipment. Another prohibits either operating an ORV that has been changed in any way so that it is louder than it was when it was brand new, or operating a vehicle without a muffler. These methods are generally not effective for several reasons.

Many ORV owners must modify the exhaust systems of their ORV's to obtain their needed operational characteristics, or to replace worn-out exhaust system components. A prohibition against modification would prevent the operator of a motorcycle with a worn-out muffler from replacing it with a quiet combination muffler/spark arrester. For some older ORV's, the stock muffler may not be available. Also, older ORV's might have been purchased new without a muffler.

The "no louder than brand new" approach is difficult to enforce because the Forest Service officer attempting to enforce such a regulation cannot establish how loud the stock vehicle was. A similar argument applies to the "muffler-required" type of regulation, since mufflers can be fit that are entirely inadequate from a noise-reduction point-of-view, but still meet the letter of the law.

Thus, the best approach to the control of ORV noise is either a numerical limit on the noise that the vehicle can emit during its operation or when tested according to a procedure correlatable with the actual noise emitted during vehicle operation (table 1). This approach is the most desirable from several points-of-view, and is the one recommended here. It is generally simplier to perform, and requires less instrumentation and training of the technician, than any other approach. It also is more repeatable, and has a better history of "standing up in court" than other approaches. The test methods given in table 1 are all "vehicle level" tests. The tests for boats and snowmobiles are performed with the vehicle under actual operation at specified operating conditions. All other vehicles are tested with the vehicle stationary, the engine running, and the transmission in neutral.

Vehicle Subclasses and Test Procedures

How to determine vehicle subclass (table 1) for motorcycles and motorboats, plus details on testing four-wheel drives (4-WD's), all-terrain vehicles, motorcycles, snow vehicles, and motorboats are given in six appendixes as follows:

- **A:** Method of dividing off-road motorcycles into three subclasses
- **B:** Method of classifying motorboats into two subclasses
- **C:** Test procedure for 4-WD's, ATV's, dune buggies, etc. (A derivitive of the procedure in appendix D.)
- **D:** SAE J1287 measurement of exhaust sound levels for stationary motorcycles [4/]

[4/] Copyright, 1980, Society of Automotive Engineers, Inc.; reproduced in appendixes by permission of SAE, Warrendale, Pa.

- E: SAE J1161 measurement procedure for snow vehicles [4/]
- F: SAE J34a measurement procedure for pleasure motorboats. [4/]

SUGGESTED ENFORCEMENT TECHNIQUES

The main objective of enforcing ORV noise regulations is to obtain compliance with the regulations and, thus, reduce the impact of ORV noise. It is *not* to issue citations or collect revenue. The Forest Service "HOST" approach is suggested. The first contact with any violator should be conversational. The Forest Service officer charged with enforcing ORV regulations should attempt to explain the environmental and social benefits of a properly silenced ORV and the detriments of one not properly silenced. If this appears to be futile (or if a second contact is necessary), a written warning that forbids further use of the vehicle on National Forests until properly silenced should be issued. [5/]

Warnings can be given on the subjective impression of the Forest Service officer if the officer has been trained to assess noisy vehicles, but a field test is more convincing. A relatively inexpensive, class 3 sound-level meter can be used to back up the enforcing officer's judgment. [6/]

After the cited vehicle is repaired, it should be required to report to a central location where someone trained in noise regulation enforcement can give a test, using a qualified sound-level meter, according to the test procedures presented in the appendixes. If, at this time, the vehicle is in conformance with the regulations, no citation should be issued and operation on National Forests should be allowed. However, if the vehicle is found again operating on a National Forest in a noisy condition, then a citation should be issued.

Enforcement can also be accomplished in an organized operational situation (e.g., when an ORV club is sponsoring an event) by making the testing and enforcement of noise regulation of all vehicles participating a prerequisite of the issuance of a special use permit. When this approach is taken, the substantial burden of testing a large number of ORV's is shifted from Forest Service personnel to the ORV club. Experience by Forest Service personnel on the Los Padres National Forest in southern California has shown that this is a very effective approach to enforcement of noise control regulations.

[4/] Copyright, 1980, Society of Automotive Engineers, Inc.; reproduced in appendixes by permission of SAE, Warrendale, Pa.

[5/] Simmons, Robert. [n.d.] Personal communication. U.S. Envir. Protect. Agcy., Denver, Colo.

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CLASSIFICATION AND SOUND LEVELS FOR OFF-ROAD MOTORCYCLES

Preliminary Draft

The U. S. Environmental Protection Agency (EPA) has classified off-road motorcycles into small and large categories; small motorcycles are deemed to be those with 170 cc or less engine displacement (45 Fed. Reg. 252, 86694 et seq and 40 CFR 250). "Closed-course competition" motorcycles are exempt from EPA sound-emission standards. A more logical approach to the classification of off-road motorcycles would seem to be by the ORV recreation objectives of land managers. This latter approach is the one used by the Society of Automotive Engineers (SAE) Motorcycle Committee Recreational Opportunities Task Force. This indicates that, because of the recreational opportunities presented on National Forests, even closed-course competition motorcycles should be sound controlled.

Nothing in the EPA regulation prevents the Forest Service from restricting motorcycle *operational* sound characteristics. Thus, restricted use of competition off-road motorcycles on Forest Service trail systems would be appropriate. In some special cases, restricting certain National Forest facilities to only small motorcycles may also be appropriate. (The maximum sound-level limits presented in table 1 of this Project Record reflect consideration of both the EPA and SAE methods.)

APPENDIX B

FOREST SERVICE CLASSIFICATION OF MOTORBOATS

Preliminary Draft

Motorboats likely to be used on National Forest waters are separated into two classes. The first, "sporting" boats (e.g., skiboats, houseboats, etc.), are those that are generally perceived as being inappropriate for mixing with nonmotorized boats (e.g., canoes, sailboats, and rowboats). The second class, "fishing" boats, contains boats that are perceived by most as being appropriate to mix with nonmotorized water recreation pursuits.

Specifically, *sporting boats* are defined as any motorboat possessing *any* of the following MINIMUM characteristics:

- Overall length of 16 ft
- Engine power of 7.5 hp (other than an auxilliary engine for a sailboat)
- Sound level (when evaluated by SAE J34a) of 82 dBA.

All other boats are *fishing boats.*

FOREST SERVICE TEST PROCEDURE FOR SOUND LEVELS OF FOUR-WHEEL DRIVE AND ALL-TERRAIN VEHICLES

Preliminary Draft

1. Scope—This document establishes the test procedure, environment, and instrumentation for determining sound levels of four-wheel drive vehicles (4-WD's), four- and six-wheel all-terrain vehicles (ATV's), dune buggies, and similar ORV's. This procedure is designed for field enforcement of sound-level limit regulations.

2. Instrumentation—The following instrumentation shall be used:

2.1. A sound-level meter meeting all requirements for type 1, 2, S1A, or S2A of American National Standards Institute (ANSI) S1.4-1971. (Note: A sound-level meter meeting all requirements for type S3A or 3 is acceptable for issuing warnings.)

2.2. A windscreen that does not affect microphone response more than ± 1 dBA for frequencies of 63 to 4,000 Hz and ± 1½ dBA for frequencies of 4,000 to 10,000 Hz, taking into account the orientation angle of the microphone.

2.3. A calibrator that is capable of checking the sound-level meter to an accuracy of ± 0.5 dBA.

2.4. A tachometer with a steady-state accuracy of ± 5 percent at the test speed.

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, which are within 5 meters (16 ft) of the vehicle being tested and the location of the microphone.

3.2. The surface of the ground within the area described in section 3.1. shall be free of loose or powder snow, plowed soil, grass of a height greater than 15 cm (6 in), brush, trees, or other extraneous material.

4. Procedure

4.1. The driver shall sit in the normal driver's position and run the engine with the gearbox in neutral at a speed specified in section 4.2. If no neutral is provided, the vehicle shall be operated either with the driving wheels 5 to 10 cm (2 to 4 in) clear of the ground, or with the drive chain or belt removed.

4.2. During sound-level measurements, the engine shall be operated at an engine speed equal to half the speed at which the manufacturer specifies that maximum horsepower is developed, ± 2½ percent of the test speed.

4.2.1. If the engine speed at which maximum horsepower is developed is not known, then the test engine speed shall be the engine speed equal to half of the manufacturer's maximum recommended engine speed (redline), ± 2½ percent of the test speed. Using half of redline at the test speed, to determine sound levels equivalent to those obtained when using half of the maximum horsepower engine speed, 3 dBA shall be subtracted from the measured sound level. (Redline is the numerically lowest speed of the red zone on the tachometer.)

4.2.2. If neither the speed at which maximum horsepower is developed nor the maximum engine speed are known, then the test speed N, ± 2½ percent, shall be used. N shall be calculated as follows:

4.2.2.1. For four-stroke vehicles, N = 250,000 ÷ engine stroke in mm, or N = 9,800 ÷ engine stroke in inches.

4.2.2.2. For two-stroke vehicles, N = 200,000 ÷ engine stroke in mm, or N = 7,900 ÷ engine stroke in inches.

5. Measurements

5.1. The sound-level meter shall be set for the A-weighting network and should be set for "slow" response. ("Fast" may be used.)

5.2. The microphone shall be located behind, 0.5 m (20 in) ± 0.03 m (1 in) from, and at the same height ± 0.03 m (1 in), as the rearmost exhaust outlet, and at a 45-degree (± 10 degrees) angle to the normal line of travel of the vehicle. The longitudinal axis of the microphone shall be in a plane parallel to the ground plan. If the rearmost exhaust outlet is under the body of the vehicle, the microphone shall be located no closer to the side of the vehicle than 0.2 m (8 in).

5.3. No wire or other means of distance measurement shall be attached to the microphone. (This may lead to erroneous readings.) However, a string or thread to measure distance may be attached to the body of the sound-level meter.

5.4. Sound-level measurements shall be made on each side of the vehicle that has an exhaust outlet. The sound level recorded shall be that measured during steady-state operation at the above-mentioned engine speed, measured on the loudest side of the vehicle. The test rpm shall also be recorded.

5.5. The ambient sound level (including wind effects) at the test site due to sources other than the vehicle being measured shall be at least 7 dBA lower than the sound level produced by the vehicle under test.

5.6. Wind speed at the test site during the test should be less than 9 m/sec (20 mph). If this is not possible, then the vehicle and measuring microphone shall be positioned so that the prevailing wind direction is parallel to the normal direction of travel of the vehicle.

6. General Comments

6.1. While making sound-level measurements, not more than one person other than the driver and the measurer shall be within 3 m (10 ft) of the vehicle under test or the microphone, and that person shall be directly behind the measurer on a line through the microphone and the measurer.

6.2. 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.

6.3. Specific items for consideration:

6.3.1. The type of microphone, its directional-response characteristics, and its orientation relative to the ground plane and the sources of sound. (Different microphones require directional orientation; therefore, consult the instruction manual for the particular microphone being used.)

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

6.3.3. Proper acoustical calibration procedure, including the influence of extension cables, etc. (Field calibration should be made immediately before the first test of each test day, and thereafter at intervals of no more than 1 hour. Internal calibration is acceptable for field use, provided that external, or acoustical, calibration is accomplished immediately before and after each test day.)

6.4. This procedure is intended for use as a pass/fail test. The limits measured by this procedure are maxima, with no additional tolerance permitted.

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

MEASUREMENT OF EXHAUST SOUND LEVELS OF STATIONARY MOTORCYCLES–SAE J1287 JUN80

SAE Recommended Practice

Report of the Motorcycle Committee, approved June 1980. Rationale statement available.

1. Scope–This document establishes the test procedure, environment, and instrumentation for determining the sound levels of motorcycles under stationary conditions. This test will measure primarily exhaust noise, but does not represent the best procedure for evaluating total vehicle noise. For this purpose, SAE Recommended Practice J331a, Sound Levels for Motorcycles, or SAE Recommended Practice J47, Maximum Sound Level Potential for Motorcycles, are recommended.

2. Instrumentation–The following instrumentation shall be used:

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

2.1.1 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or other indicating instrument, provided the system meets the requirements of SAE Recommended Practice J184a, Qualifying a Sound Data Acquisition System.

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

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

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

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

3. Test Site

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

3.2 The surface of the ground within the area described in paragraph 3.1 should be asphalt, concrete, or hard packed earth, level within an average slope of 40 mm/m, (0.5 in/ft) and shall be free of loose or powdered snow, plowed soil, grass of a height greater than 150 mm (6 in), trees, or other extraneous material.

4. Procedure

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

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

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

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

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

5. Measurements

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

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

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

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

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

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

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

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

5.9 Acoustic calibration of the sound level meter shall be made immediately before the first test of each test day, and should be made at the end of each test day. Field calibration should be made at intervals of no more than 1 h.

6. General Comments

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

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

6.3 Specific items for consideration:

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

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

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

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

6.5 The use of the word *shall* in the procedure is to be understood as obligatory. The use of the word *should* is to be understood as advisory. The use of the word *may* is to be understood as permissive.

7. References

1. SAE J331a, Sound Levels for Motorcycles.
2. SAE J47, Maximum Sound Level Potential for Motorcycles.
3. ANSI S1.4-1971 (R1976), Specification for Sound Level Meters.
4. SAE J184a, Qualifying a Sound Data Acquisition System.
5. SAE J245, Engine Rating Code-Spark Ignition.

APPENDIX

This procedure is intended to be adapted to a variety of uses, which may include exhaust system certification, enforcement of in-use motorcycle standards, and use by motorcycle competition bodies to ensure some silencing of race vehicles. Some of these uses may require less precision than is called for in the procedure. Accordingly, the following changes may be made for convenience, with the realization that accuracy may suffer.

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

A.2 Instrumentation–Type 1 instrumentation, which generally can provide the most accurate measurements, should be used when the need for accuracy is great, such as certification of exhaust systems, or enforcement action which may result in some form of penalty. Type 2 instrumentation should be appropriate for some enforcement work, such as a preliminary screening test, or for general data gathering. On the other

hand, Type 3 instrumentation, which is less precise than Type 1 or Type 2, may be appropriate in cases such as a racetrack or motorcycle park that is primarily interested in securing some noise reduction from the motorcycles operated within, and not measuring for the purpose of meeting specified maximum noise limits. Selection of equipment should reflect the need for accuracy (particularly considering any consequences) balanced against cost.

A.3 Procedure—When making comparison measurements where a single variable is to be evaluated, such as comparing the sound level of two different exhaust systems on the same vehicle, selection of the correct engine speed according to paragraph **4.1** is not critical as long as the same engine speed is used for each test.

A.4 Enforcement Testing—In enforcement situations, it is often easier to use one half of the *redline* speed rather than the test speed specified in Section 4. *Redline* speed is the lowest numerical engine speed included in the red zone on the motorcycle tachometer. If one half of redline speed is used in this test rather than one half of the maximum rated net horsepower speed, an appropriate tolerance must be added. Since one half of redline is a higher test speed than one half of rated rpm, the measured sound level will be higher, and a 3 dB tolerance must be added to the applicable sound level limit.

A.5 Racing Motorcycles—This test procedure can be used for sound testing of racing motorcycles. The appropriate test speed for both four-stroke and two-stroke racing motorcycles is determined from the formula:

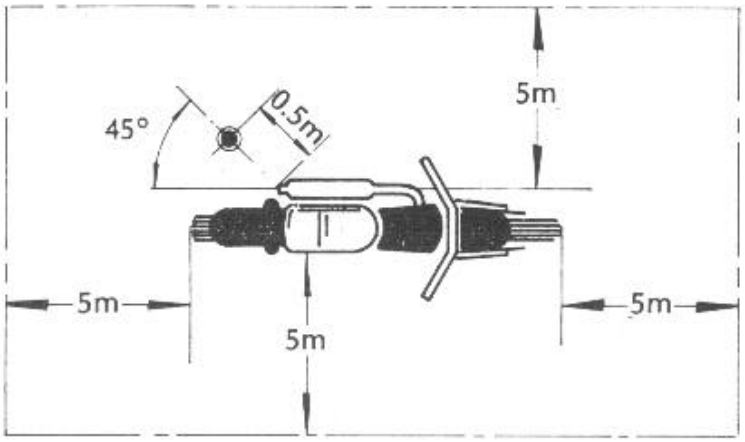
$$\text{Test Speed} = \frac{306\,000}{\text{stroke in millimeters}} \text{ or } \left(\frac{12\,000}{\text{stroke in inches}}\right)$$

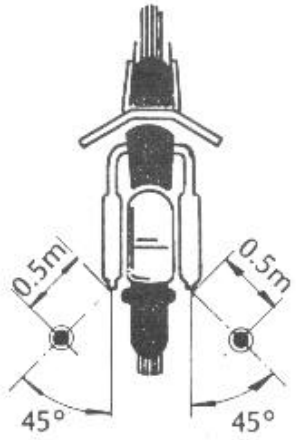
A.6 Use of slow dynamic response is specified, but fast dynamic response may be used. Because of the essentially constant nature of the sound level, either mode is acceptable; the meter is easier to read when slow response is used.

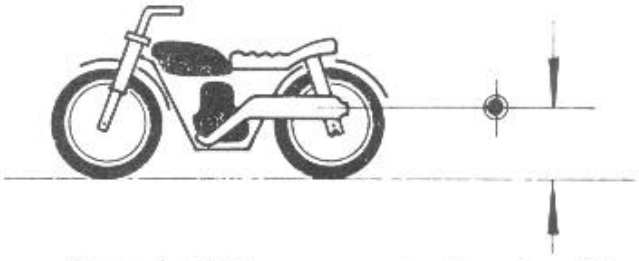
A.7 Wind Speed—If it is not possible to delay testing until the specified wind conditions prevail, testing can be performed in higher winds. In this case, the motorcycle should be positioned so that the prevailing wind direction is parallel to the normal direction of travel of the motorcycle.

Diagrams of the Motorcycle and Microphone Arrangement

(From Motorcycle Industry Council (MIC) Test Procedure E-79 for Sound Levels of Stationary Motorcycles)







Same height as rearmost exhaust outlet

LEGEND

◉ Microphone

5 meters = 16 feet

0.5 meters = 20 inches

APPENDIX E

OPERATIONAL SOUND LEVEL MEASUREMENT PROCEDURE FOR SNOW VEHICLES—SAE J1161 APR80

SAE Recommended Practice

Report of the Off-Road Sound Level Committee, approved November 1976, reaffirmed without change April 1980. Rationale statement available.

1. Scope—This recommended practice establishes the instrumentation, test site, and test procedure for determining the exterior operational sound level for snowmobiles.

2. Instrumentation—The following instrumentation shall be used, where applicable, for the measurements required:

2.1 A precision sound level meter which meets the Type 1 requirements of American National Standard Specification for Sound Level Meters (S1.4-1971).

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

2.1.2 The microphone shall be used with a windscreen that will not affect the microphone response by more than ±1 dB for frequencies of 20–4000 Hz or ±1.5 dB for frequencies of 4000–10 000 Hz at zero wind speed conditions.

2.2 An acoustic calibrator (accuracy within ±0.5 dB).

2.3 A calibrated vehicle speed indicating system (accuracy within ±5% at test speed).

2.4 A thermometer (accuracy within ±1°C [2°F]).

2.5 A barometer (accuracy within ±1 %).

2.6 A psychrometer or dew point apparatus.

2.7 An anemometer (accuracy within ±1%).

2.8 A windvane or other device for the measurement of wind direction.

3. Test Site

3.1 A suitable test site is a level open space free from the effects of large sound reflecting surfaces. Parked vehicles, signboards, and other obstacles must not be located within 30.4 m (100 ft) of either the vehicle path or the microphone (see Fig. 1).

3.2 The microphone shall be located 15.2 m (50 ft) from the centerline of the vehicle path and 120 cm (48 in) above the snow or turf. The normal to the vehicle path from the microphone shall establish the microphone point on the vehicle path.

3.3 The measurement area shall be the triangular area formed by the start point, the end point, and the microphone location.

3.4 The surface of the ground within the measurement area, including the vehicle path, shall be covered with a maximum of 7.5 cm (3 in) loose snow over a base consisting of at least 5 cm (2 in) of snow sufficiently compacted to support the snowmobile without penetration. As an alternative, a surface of turf, primarily grass up to a maximum of 7.5 cm (3 in) in height may be used, which, except for the vehicle operating path, shall be free of visible droplets of water.

3.5 The reference point of the vehicle, to indicate when the vehicle is at any of the points on the vehicle path, shall be the front of the vehicle skis.

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

3.7 The ambient A-weighted sound level (including wind effects) coming from sources other than the vehicle being measured, shall be at least 10 dB lower than the noise level with the vehicle operating under test conditions.

4. Procedure

4.1 Vehicle Operation—A constant speed as specified below is the basis for determining the operational sound level of the snowmobile.

4.1.1 Before reaching the start point, accelerate the vehicle to the speed of 24 + 3 km/h (15 ± 2 mile/h). Maintain this constant speed with throttle held as steady as possible through to the end point. The centerline of the vehicle must not deviate more than 1 m (3 ft) from either side of the centerline of the vehicle path.

5. Measurements

5.1 The sound level meter shall be set for *slow* response and the A-weighted network.

5.2 The applicable sound level reading shall be the highest indicated for the run, between the start point and the end point, ignoring unrelated peaks due to extraneous noise.

5.3 During the test period, the atmospheric temperature, pressure, humidity, wind speed, and wind direction shall be recorded at intervals not to exceed one h. Also record test surface conditions.

5.4 Test runs shall be repeated until three readings within a 2 dB range per vehicle side have been obtained. The sound level for each side of the vehicle shall be the average of all three readings, rounded to the nearest integer. The sound level reported shall be that for the side of the vehicle with the highest average.

6. General Comment

6.1 It is recommended that persons technically trained and experienced in the current technique of sound measurement select the equipment and conduct the tests.

6.2 The operation of recording and measuring equipment is likely to be affected by low temperatures. Where measurements are undertaken at temperatures near or below 0°C (32°F), special precautions must be taken to ensure the reliability of sound meter readings and/or recordings.

6.3 Instrument manufacturers' specifications for the proper use of all the test equipment shall be adhered to.

6.4 Measurements shall be made only when the wind speed is below 19 km/h (12 mile/h) and absolute barometric pressure is between 93 and 103 kPa (27.5 and 30.5 in of mercury).

6.5 The vehicle manufacturers' recommendation governing the proper operation of the vehicle shall be followed.

6.6 Proper acoustical calibration procedure shall 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 external calibration is accomplished immediately before and after field use.

6.7 A 2 dB tolerance over the sound level limit shall be included to provide for variations in test sites, temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles.

7. Reference Material—Suggested reference material or subsequent revisions thereof, is as follows:[1]

7.1 ANSI S1.1-1960 (R-1971) Acoustical Terminology.

7.2 ANSI S1.2-1962 (R-1971) Method for the Physical Measurement of Sound.

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

7.4 ANSI S1.3-1971 Methods for the Measurement of Sound Pressure Levels.

7.5 SAE J184—Qualifying a Sound Data Acquisition System.

[1] Application for copies of references 1–4 should be addressed to:
The American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

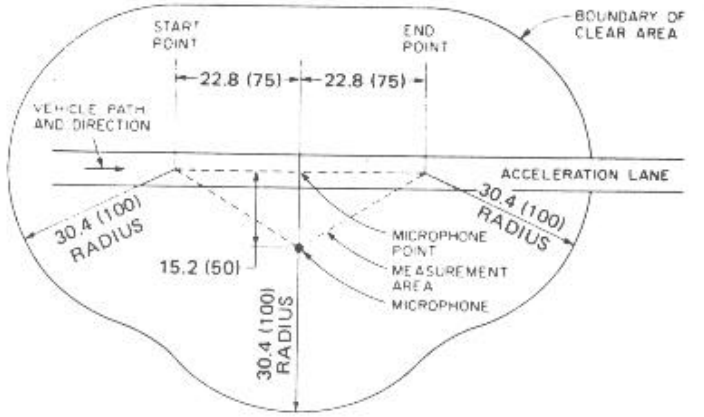


FIG. 1—UNIDIRECTIONAL TEST SITE LAYOUT

APPENDIX F

EXTERIOR SOUND LEVEL MEASUREMENT PROCEDURE FOR PLEASURE MOTORBOATS—SAE J34a

SAE Recommended Practice

Report of Vehicle Sound Level Committee approved April 1953 and last revised by Specialized Vehicle and Equipment Sound Level Committee April 1977. It is strongly recommended that the user of this document obtain a copy of the companion document from SAE Headquarters.

1. Scope—This SAE Recommended Practice establishes the procedure for measuring the maximum exterior sound level for pleasure motorboats under 20 m (65 ft) in length, and describes the instrumentation, test site, and boat operation, for determining the sound level.

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

2.1 A precision sound level meter which meets the Type 1 requirements of ANSI S1.4-1971, Specification for Sound Level Meters.

2.1.1 The microphone shall be used with an acceptable foam wind screen. To be acceptable the wind screen shall not affect the overall reading by more than ±0.5 dB(A) for the sound source that is being measured. (See paragraph 4.4).

2.2 A sound level calibrator (See paragraph 4.3).

2.3 A wind speed anemometer.

2.4 An engine speed tachometer.

3. Procedure

3.1 Test Site—A suitable test site is a flat calm body of water, large enough to allow full speed pass-bys. The area around the microphone and boat shall be free of large obstructions, such as buildings, boats, hills, large piers or breakwater, etc. for a minimum distance of 30 m (100 ft). Three markers (buoys or posts) will be placed in line, 15 m (50 ft) apart, to mark the course the boat is to follow while being tested.

3.1.1 The background sound level (including wind effects) shall be at least 10 dB lower than the measured level of the boat being tested.

3.2 Boat Operation

3.2.1 The boat shall pass all three markers on a straight course at wide-open throttle with the engine operating at the midpoint of the manufacturers recommended full throttle rpm range. (See companion document for further information.)

3.2.2 The engine speed tolerance shall be ±100 rpm if this falls in the recommended full-throttle speed range. If a single top speed rpm is recommended, the tolerance shall be +0, −100 rpm.

3.2.3 Boats which are sold with the power units installed (for example, inboards, and stern drives) shall be tested in this combination. Outboard motorboats shall be tested with a motor or motors for which the boat is rated, since sound level is dependent upon boat design and construction.

3.3 Measurements

3.3.1 The microphone shall be placed 25 m (82 ft) from the line determined by the three markers, normal to the line and opposite the center marker. It shall also be placed 1.2–1.5 m (4–5 ft) above the water, and no closer than 0.6 m (2 ft) from the surface of the dock or platform on which the microphone stands. It shall be placed as near to the end of the dock as possible or overhanging the end of the dock.

3.3.2 The meter shall be set for fast response and the A-weighting network.

3.3.3 The meter shall be observed while the boat is passing within 0.5–1 m (approximately 1–3 ft) on the far side of all three markers. The applicable reading shall be the highest sound level obtained for the run rounded to the nearest 0.5 dB. At least two measurements shall be made for each side of the boat. All values shall be recorded.

3.3.4 The sound level for each side of the boat shall be the average of the first two readings which are within 1 dB of each other rounded out to the nearest 0.5 dB. Care should be taken to avoid higher than normal readings which may be the result of unusual boat motion due to waves and wakes. The sound level reported shall be that of the loudest side of the boat.

4. General Requirements

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

4.2 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be consulted for both recommended operation of the instrument, and precautions to be observed. Specific items to be considered are:

4.2.1 The type of microphone and its orientation relative to the source of noise.

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

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

4.3 Proper acoustical calibration of the complete measurement system shall be performed immediately before and after each field use. Field calibration, which may be accomplished by either external or internal calibration means, shall be made immediately before and after each test sequence, provided that system acoustical calibration is performed immediately before and after field use.

4.4 Measurements shall be made only when the wind speed is below 19 km/h (12 mph). A wind screen shall be used at all times to minimize wind effects.

4.5 Because bystanders may have an appreciable influence on meter response when they are in the vicinity of the microphone, no person shall be within 1 m of the microphone. Not more than one person other than the observer reading the meter shall be within 15 m (50 ft) of the microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

5. References—Suggested reference material is as follows:

5.1 ANSI S1.1-1960 Acoustical Terminology

5.2 ANSI S1.4-1971 Specification for Sound Level Meters

5.3 ANSI S1.2-1962 Physical Measurement of Sound

5.4 ANSI S1.13-1971 Methods for the Measurement of Sound Pressure Levels

Applications for copies of these documents should be addressed to the American National Standards Institute, Inc. 1430 Broadway, New York, New York 10018.

APPENDIX

This procedure is based on wide-open throttle operation at 25 m from the shoreline. Motorboats seldom are operated in this manner, therefore, the procedure yields an overestimate of the typical sound level at the shoreline. Under actual operating conditions the sound level created by any motorboat will depend on the manner in which the boat is operated, the distance from the motorboat to the listener, hull and structural design of the boat, water conditions, atmospheric attenuation of the sound, etc. (See companion document for further information.)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