550/9-74-011

LAWN MOWERS:
NOISE AND COST OF ABATEMENT

JUNE 1974

U.S. Environmental Protection Agency
Washington, D.C. 20460

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JUNE 1974

Prepared For:

U.S. Environmental Protection Agency
Office of Noise Abatement and Control

Under Contract No. 68-01-1539

"I appreciate what you've done about the noise of your power mower, Adams!"

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FOREWORD

The Environmental Protection Agency is publishing a series of reports prepared by contractors describing the technology, cost, and economic impact of controlling the noise emissions from commercial products. It is hoped that these reports will provide information that will be useful to organizations or groups interested in developing or implementing noise regulations. This report was prepared by Bolt, Beranek, and Newman under EPA Contract 68-01-1539.

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1. INTRODUCTION

The manufacture of lawn care equipment accounts for sales of $700 million annually, of which $550 million goes to power lawn mowers. There are 95 manufacturers listed in Thomas' Register and probably well over 200 altogether in the United States. For this study, we contacted by telephone or letter about 35 of the larger manufacturers; six of the more helpful manufacturers were then visited directly. A list of the manufacturers contacted is given in Appendix A.

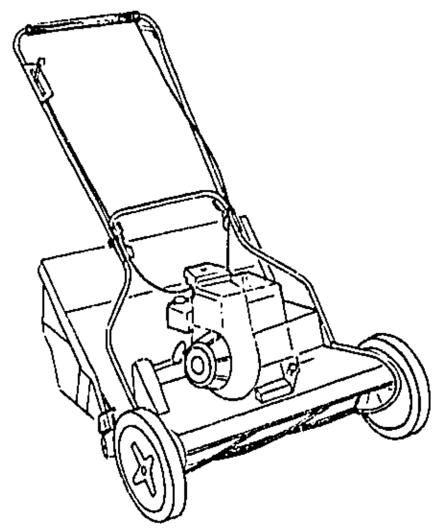
For the small manufacturer, lawn mower fabrication is primarily an assembly operation involving the purchase of many of the parts required. Ninety-five percent of all lawn mowers use either Briggs and Stratton or Tecumseh engines. Only two manufacturers make some of their own engines. A number of large manufacturers specialize in the "Private Label" market where they do not market under their own names but sell to large chain stores or distributorships.

Unconventional substitutes for power lawn mowers have not been considered seriously in this report. Such unconventional approaches include plastic lawns, sheep, horses, and chemical growth retardants.

2. CURRENT LAWN MOWERS

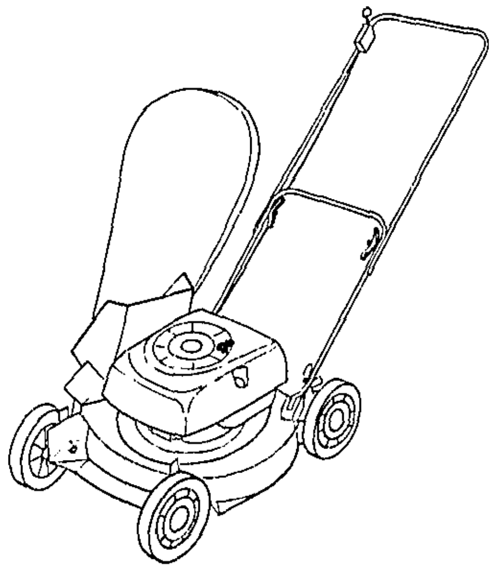
The oldest type of power lawn mower currently in use is the gasoline reel or barrel mower. The reel consists of five or six helical blades which bear upon a cutter bar. The mower relies upon a scissors type of action to cut the grass. When the mower is adjusted so that the reel and cutter bar do not quite touch, the reel can be very quiet. In this case, the engine is the major noise source.

About twenty years ago, the rotary type of gasoline-powered mower started to become popular. The rotary mechanism consists of a two-arm blade rotating about a vertical axis. The blade relies on it speed to cut grass, requiring a tip speed of between 16,000 and 19,000 feet per minute (fpm) to give a good cut. The sharpness of the blade has little to do with the actual cutting process, this being determined primarily by the blade speed, but sharpness does determine whether the ends of the grass blades become bruised or split. Because of their high speed, the blades on rotary mowers are noisier than those of reel mowers.



REEL MOWER

Several modifications of the basic rotary mower are now on the market. Designers found that cutting quality was improved by putting lift on the blade by shaping it like an airfoil, so that the grass blades are sucked up before they are cut. This lift can also be used to pick up the grass clippings and throw them into a catcher bag. Other mowers retain grass clippings within the housing and chop them up into a mulch. In addition, some walk-behind mowers offer a self-propelled feature.

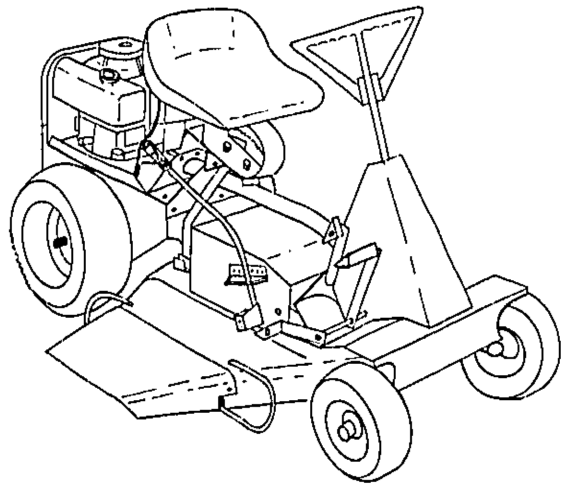


GASOLINE POWERED ROTARY MOWER

In recent years, the popularity of riding mowers has increased. They use the same cutting principle as the walk-behind rotary mowers, but do not usually bag the grass clippings. Riding mowers tend to have more powerful engines and larger structures than do walk-behind mowers. These structures act as sounding boards for engine-induced vibration. Hence, riding mowers tend to make more noise. Both walk-behind and riding rotary mowers are available with electric power.

For very large mowing operations, lawn tractors are used with mowing attachments, but these tractors are not considered to be within the scope of this investigation.

Lawn mowers are sized according to both installed engine horsepower and cutting width. The ranges are listed in Table I.



RIDING MOWER

TABLE I. SIZE RANGES OF LAWN MOWERS

Type	Installed hp	Cutting Width
Reel	2 to 2-1/2 hp	18 to 21 in.
Walk-Behind Rotary	3 to 5 hp	18 to 22 in.
Riding Rotary	5 to 8 hp	22 to 36 in.

The number of lawn mowers sold in 1970, together with their dollar value, is listed in Table II [1].

TABLE II. SALES DISTRIBUTION OF LAWN MOWERS (1970)

Type	Number of Units	Dollar Volume
Reel	130,383	$ 12,993,686
Walk-Behind Rotary	4,056,059	229,755,763
Riding Rotary	889,432	318,839,378
	5,075,874	$561,588,827

It may be seen that walk-behind rotary mowers are by far the most numerous but that riding rotary represent the largest dollar volume. The volume of reel mowers is only a few percent of rotary mowers.

2.1 Noise Ordinances

Many cities and states have ordinances governing noise from lawn equipment. Most well-known is the Chicago City Ordinance, which sets a sliding time scale for equipment to achieve a given noise level. These levels are listed in Table III.

TABLE III. CHICAGO CITY ORDINANCE LEVELS FOR LAWN MOWERS

Date	Level at 50 ft
Manufactured after 1 January 1973	74 dB(A)
Manufactured after 1 January 1975	70 dB(A)
Manufactured after 1 January 1978	65 dB(A)

A manufacturers' association, the Outdoor Power Equipment Institute (OPEI), has laid down a voluntary noise level criterion at the operator's ear of 92 dB(A) for walk-behind mowers and 95 dB(A) for riding mowers. The OPEI standard covers many other safety aspects of lawn mowers and all equipment which complies is entitled to carry the OPEI sticker. Compliance is verified by an independent testing laboratory.

2.2 NIPCC Report

In 1971 the National Industrial Pollution Control Council (NIPCC) of the U.S. Department of Commerce published estimates of feasible noise control goals for leisure time products including walk-behind and riding mowers [1]. The goals and costs of their implementation are listed in Table IV.

TABLE IV. NIPCC NOISE GOALS AND ABATEMENT COSTS

Date	1970	1973	1978	1983
Cost Increase (% 1970 price)	0	5%	15%	30%
Walk-Behind Mowers [Levels in dB(A)]				
At user's ear	92	88	85	82
At 50 ft	68	68	64	62
Riding Mowers [Levels in dB(A)]				
At user's ear	95	90	85	82
At 50 ft	78	73	68	65

For walk-behind mowers between 1970 and 1973, a 4-dB(A) reduction at the operator's ear is predicted, with no reduction in the level at 50 ft. This estimate is hard to understand.

The levels being considered in this report are very similar to those listed in Table IV. However, we have been able to get a more exact idea of how the levels will be achieved and have obtained more accurate cost estimates. If the full distributor's mark-up is applied, then our cost estimates are comparable to those above.

2.3 Lawn Mower Industry

There are over 200 lawn mower manufacturers in the United States. They range in size from the large multimillion dollar corporations with full-size engineering departments to small job-shop operations. Only two of the larger corporations manufacture their own 2-cycle engines, all other companies buying their 4-cycle engines from either Briggs and Stratton or Tecumseh. The small manufacturers also buy the lawn mower decks, cutting blades, wheels, and handles and assemble these into the final lawn mower. Many of the larger manufacturers sell similar models under different brand names (private labels).

There are about 15 large manufacturers with engineering departments capable of developing an acoustically treated lawn mower. The other manufacturers rely on their suppliers for design information, usually Briggs and Stratton who supply the engines and can also provide some information on mufflers and engine acoustic treatment. However, Briggs and Stratton do not offer any information on how to quiet the lawn mower blade since this is not their business.

Mark-ups

Manufacturers' costs for noise reduction are very different from the cost to the consumer, the difference being comprised of manufacturer's overhead and profit, distributor's mark-up, and retailer's mark-up. Some chain stores are able to buy directly from the manufacturer and eliminate the distributor's mark-up. A typical breakdown for a nominal $1.00 item is as follows:

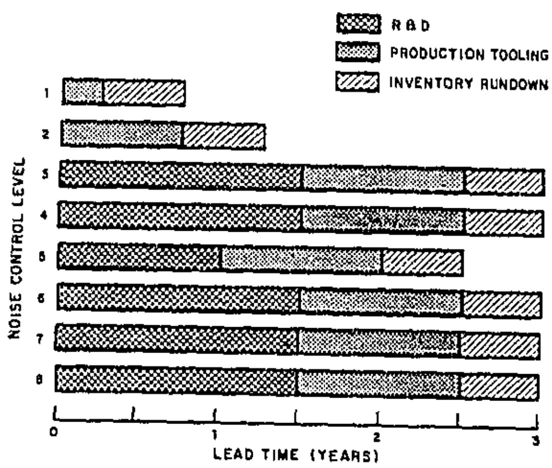
Manufacturer's Cost	$1.00
Manufacturer's Selling Price	$1.50
Distributor's Selling Price	$2.10
Retailer's Selling Price	$3.00
Price to Consumer	$2.00 - $4.00

These ratios may be larger for some "prestige" models for which the manufacturer conducts large-scale national advertising. Also, the mark-up on spare parts can be very large. For example, a 15¢ muffler can cost the consumer $2.20.

Mark-up can also be considerably lower than the above figures. A manufacturer may apply a much lower mark-up for a bought out item, such as the engine. For example, the engine on a lawn mower which retails for $52.00 costs the *manufacturer* $24.00. If a *consumer* wished to purchase a spare engine it would cost about $70.00.

Manufacturing Schedules and Lead Time

The model year for lawn mowers starts in August of the previous year, and the engineering design is frozen one year before that. Thus, a 1975 mower appears in August of 1974, but its design is frozen on August 1, 1973. Typically, there will be a year of development engineering on the initial design. Thus, it takes a total of 2-1/2 years from initial design to 1 January of the model year. If the design has to be deduced from known technology, the process may take three years. Hence, three years is the minimum lead time required for a significant change in noise levels.



Differential Effect of Regulations on Companies

The effect of noise regulations will vary with the size of the company. It is likely that the 15 large companies with engineering departments will be able to redesign and develop their products to meet the various levels of noise reduction in proposed regulations. Smaller companies, who will have to rely upon others to quiet their machines, will have to buy from suppliers such noise-controlled items as engine enclosures or quiet blades.

In the survey, there was no evidence of any significant cost differences to small or large manufacturers. For example, engines and mufflers are priced by cases of 30 or 60 units. The price is the same whether one purchases 1 or 10,000 cases. (There is a 6% discount for spreading delivery.) A small manufacturer will have to purchase items from a larger manufacturer, who will presumably apply his mark-up. However the small manufacturer will not have the development and tooling costs. The cost estimates given in Secs. 4 and 5 are, in any case, very rough, since even the large manufacturers have a very poor estimate of their costs and the small manufacturers have not even considered the question.

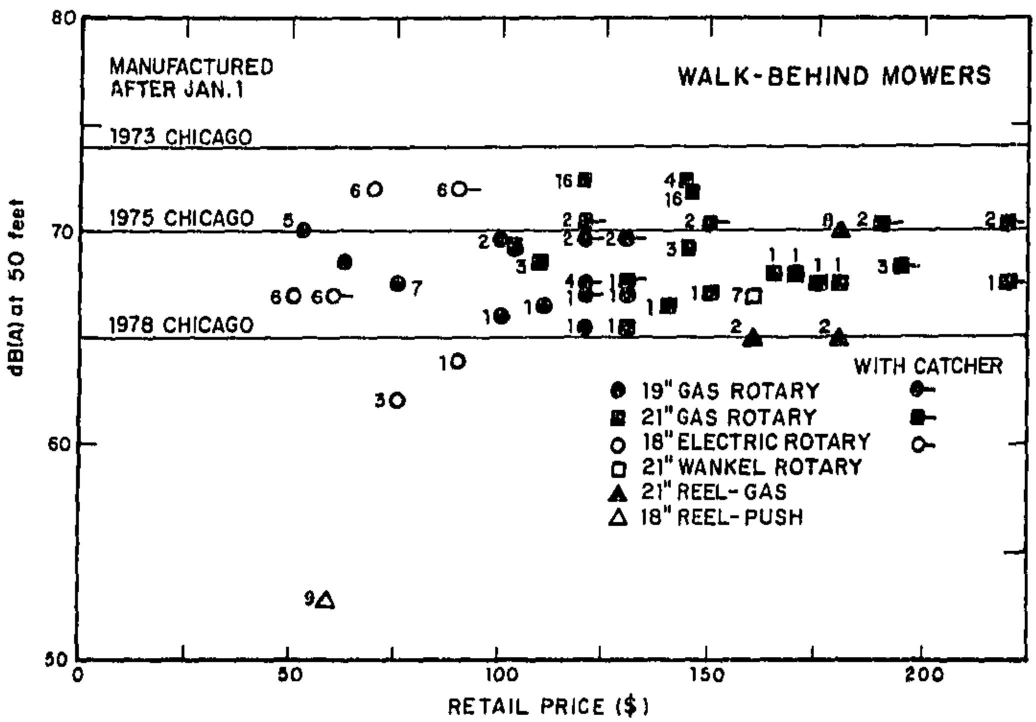
Universally, the estimated cost of a major design change for most large manufacturers was the same: $250,000. This cost is attributable to retooling and is almost independent of the actual change made.

3. BASELINE NOISE LEVELS

As shown in Sec. 2.1, there are some noise control standards for lawn mowers. These standards have resulted in some degree of noise control. Just about all mowers currently manufactured comply with the voluntary OPEI standards of 92 dB(A) at the operator's ear for walk-behind mowers and 95 dB(A) for riding mowers. All walk-behind mowers comply with the current Chicago ordinance of 74 dB(A) at 50 ft and many comply with the 1975 level of 70 dB(A) at 50 ft. However, many riding mowers do not comply with the current Chicago ordinance, and none comply with the 1975 level.

Because noise control generally costs money and manufacturers have *not* found quiet to be a very good selling point, there has so far been little incentive to quiet lawn mowers. From 1958 to 1960, Lawnboy and Dille & McGuire both marketed very quiet lawn mowers with noise levels of about 58 dB(A) at 50 ft [about 10 dB(A) below current levels], but their cost was about 30% more than comparable mowers. These mowers had the full noise control treatment discussed in Sec. 4 (Level 8), but they were smaller and did not bag grass so well as other machines. The mowers did not sell and, since then, manufacturers have been apprehensive of being at a competitive disadvantage if they produce a machine which is quieter than it has to be but consequently more costly. However, sensing an emerging public awareness of noise pollution, one leading manufacturer plans to market a quieter mower in the fall of 1973.

The noise levels of current walk-behind rotary mowers at 50 ft and at the operator's ear are listed by model in Appendix C and illustrated in Figs. 1 and 2. Corresponding noise levels of riding mowers are shown in Figs. 3 and 4. The noise levels are plotted as a function of price, although, as will be discussed



Code of Manufacturers

1. Lawnboy
2. Toro
3. Sears, Roebuck
4. Simplicity
5. Polaron
6. Black & Decker
7. General Leisure Products
8. Jacobsen
9. Scott
10. International Harvester
11. Huffman Eng.
12. General Electric
13. John Deere
14. MTD
15. Murray Ohio
16. Hahn Eclipse

FIG. 1. NOISE LEVELS OF WALK-BEHIND MOWERS AT 50 FT.

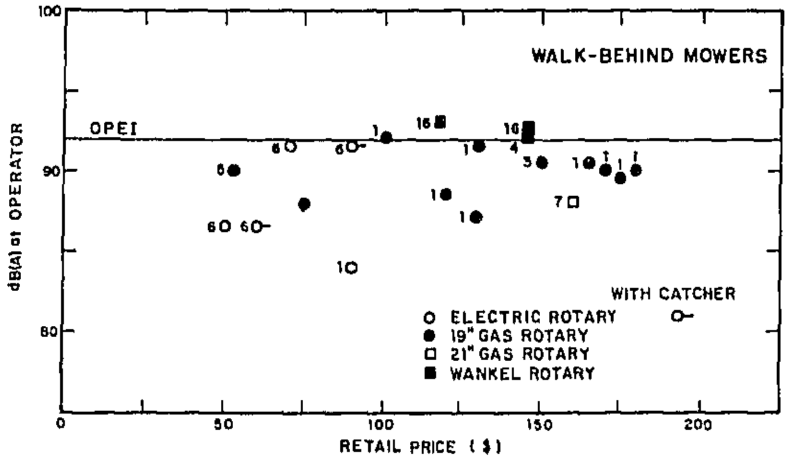


FIG. 2. OPERATOR'S EAR NOISE LEVEL OF WALK-BEHIND MOWERS.

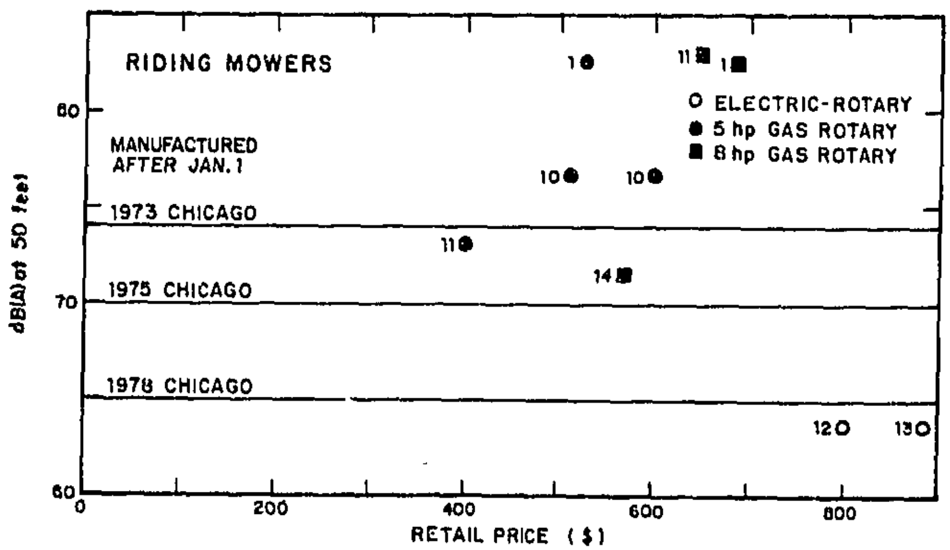


FIG. 3. NOISE LEVELS OF RIDING MOWERS AT 50 FT.

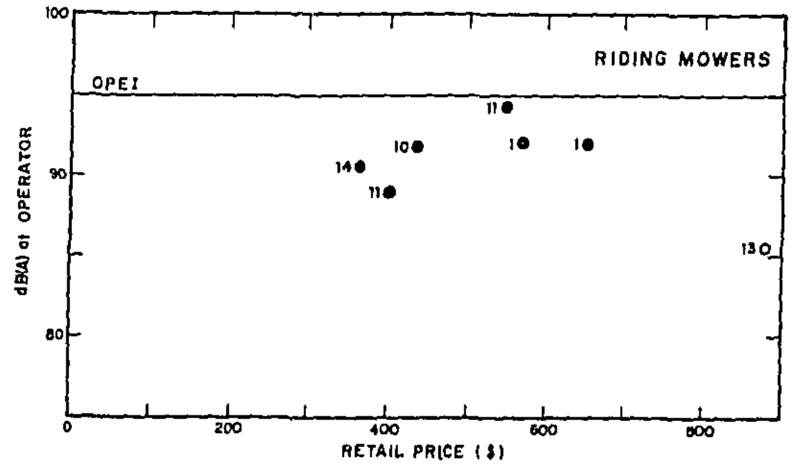


FIG. 4. NOISE LEVELS OF RIDING MOWERS AT OPERATOR'S EAR.

further in Sec. 3.1, there is no correlation. One pays the extra money on a mower, not for quiet, but for die cast deck, self-propulsion, electric starter, or grass bag. Most mowers use very similar engines, by far the most popular being the Briggs and Stratton 3.5 hp for walk-behind mowers. One often finds essentially the same engine on a $70.00 or $200.00 machine. The range of noise levels is summarized in Table V.

TABLE V. NOISE LEVEL RANGES OF ROTARY LAWN MOWERS IN dB(A)

	At Operator's Ear	At 50 ft
Walk-Behind Mowers:		
Gasoline	87 to 92	65.5 to 72
Electric	86 to 92	62 to 68
Riding Mowers:		
Gasoline	90 to 95	72 to 83
Electric	--	63

One interesting fact which emerges is that electric walk-behind mowers are not much quieter than gasoline mowers. The reasons are that the noise from the rotating blade is the dominant source and that a high-speed electric motor is also extremely noisy. A Wankel engine powered mower has also been measured, but it was not significantly quieter than any other mowers.

Correlation between noise levels at the operator's ear and at 50 ft is shown in Table 5. The correlation is quite good, indicating that a noise regulation at, say, the 50-ft level will benefit both the community and the operator by the same reduction in level from present values.

Some measurements have been made on a manually propelled lawn mower which produced 53 dB(A) at 50 ft. These measurements are discussed in Appendix C.

3.1 Reasons for Differences in Noise Levels

To explore some reaons for differences in noise levels among lawn mowers, consider the model line as given in Table VI.

TABLE VI. COST AND NOISE LEVELS OF ONE MANUFACTURER'S MOWER LINE

Model	19 in.	21 in.	Electric Start 19 in.	Self-Propelled 19 in.	Self-Propelled 21 in.	Electric Start Self-Propelled 21 in.
Price $	130	150	160	170	190	220
Noise Level [dB(A) at 50 ft]	69.5	70.5	69.5	69.5	70.5	70.5

Table VI shows that one pays $30.00 for electric start and $40.00 for self-propulsion, with no noise abatement. (The engine and blade are identical.) $20.00 more for the larger machine purchases slightly higher noise levels because of the slightly larger engine and blade. As another example, consider the mowers one can buy for $120.00 as shown in Table VII.

TABLE VII

Model	Capacitor Discharge Ignition 19 in.	With Catcher 19 in.	19 in.	19 in.	21 in.	20 in.
Noise Level [dB(A) at 50 ft]	65.5	67.5	68	69.5	70.5	72
	Good Muffler/ Slower Blade		Different Manufacturers			

Here the mower with the grass catcher is noisier because more of the underside of the deck is exposed. However, this manufacturer's catcher design is unique and, in general, the noise difference owing to the catcher is not significant. Noise levels vary from one manufacturer to another, possibly because of variations in measuring conditions. These variations should disappear when the proposed SAE code of measurement practice is adopted. Other factors are

Different Blade Lift	–	More lift often means more noise but better bagging.
Different Blade Clearances	–	Less clearance means more noise.
Different Engine Governor Speeds	–	Manufacturers set engines to run at different speeds. OPEI limits blade tip speed to 19,000 fpm. Some mowers are closer to this limit than others.

It has *not* generally been found that the type of deck, steel or magnesium, makes much difference unless a very thin steel deck is used.

An electric mower with twin 9 in. blades rotating at 7,200 rpm has very high motor noise. Single rotor mowers rotating at 3,600 rpm were much quieter.

For the case of riding mowers, there is a large difference in the noise levels produced by 5-hp and 8-hp machines, the 8-hp engine being about 5 dB(A) louder. Other differences arise mainly from the use of different mufflers. There are usually no significant differences in noise levels produced by similar horsepower engines of different manufacturers. They are all aluminum and air-cooled. Briggs and Stratton and Tecumseh engines carry identical prices, but engines made by the lawn mower manufacturers themselves cost a little more.

3.2 Measurement Standards

There are currently two relevant standards for the measurement of lawn mower noise: American National Standards Institute (ANSI)B 71.1 (1972) - Operator's Ear Noise - and Society of Automotive Engineers (SAE) J952b - Community Noise at 50 ft. Both standards describe how to take the noise measurements as well as all necessary precautions. The SAE, however, has not found its standard to be sufficiently detailed and consistent and is in the process of developing a new code of practice. A draft of this standard is included as Appendix B.

The new SAE code of practice aims at simulating the noise levels generated under operating conditions. For this reason, the tests measure the highest sound levels of a mower as it is driven or walked by the measuring point. The type of surface over which the noise measurements are made causes a significant difference in the results. The hardness of the ground and state of the grass both have an influence, thereby indicating that results are not repeatable from summer to winter. Consequently, the SAE subcommittee employs a synthetic grass surface to obtain even results. "Tartan Turf" (made by the Minnesota Mining and Manufacturing Corp.) is glued to 1/2 in. to 3/4 in. plywood. The area covered is a right-angled isosceles triangle with a long side of 46 ft (see Fig. 5). The walk-by or drive-by takes place on the long side with the observer holding a sound level meter at the right angle. The setup requires twenty-eight panels 8 ft × 4 ft.

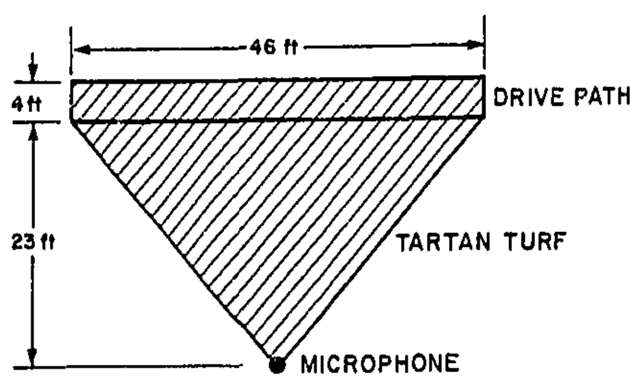


FIG. 5. SAE TEST GEOMETRY.

The SAE subcommittee has also found that the loading on the mower affects its noise level. A walk-behind mower makes the greatest noise when it is *not* cutting, because the blades, which are the main source of noise, move faster when unloaded. However, a riding mower, in which the engine is the dominant source, makes the most noise cutting long grass, because the engine is working hardest then. Thus, the SAE specifies that riding mowers tow a load when measurements are made. This condition can make as much as 7 dB(A) difference in the noise. Consequently, walk-behind and riding mowers must be measured with slightly different procedures.

The revised SAE noise measurement standards have been carefully developed and have received wide acceptance in the industry. It therefore seems reasonable that they be used for lawn mower noise performance standards.

Equipment costs for performing these noise measurements are $1500 for the special surface and $1000 for a precision sound level meter. Each mower can be tested in half an hour.

3.3 Measures of Performance

Lawn mower performance is judged on the basis of cutting and possibly of bagging grass. There are no objective measures of these quantities, but manufacturers are generally agreed on the performance criteria. As mentioned above, a high blade-tip speed (16,000 to 19,000 fpm) is required for a good cut. If the blade is slowed, one way of reducing its noise, then its performance in thick grass and weeds will degrade. Tufts of grass may be left uncut and have to be gone over again. Roughly speaking, a 10% reduction in blade speed will mean that it will take 10% longer to mow a given lawn.

The bagging ability of a mower is primarily determined by the lift on the blade. If a blade is slowed, then its lift will be reduced and it will not fill the bag as densely with lawn clippings. Typically, a 10% reduction in speed will mean that the bag will have to be emptied 10% more often.

3.4 Statistical Variations in Noise Level

Because of manufacturing variations and differences in measuring conditions, there will be statistical variations in the noise levels of a given model.

Manufacturing Variations

It is generally agreed by manufacturers that changes of ±1.5 dB(A) are observed for different samples of the same model of machine.

Observer Variations

Changes of ±1 dB(A) are found for different observers making the same measurement on the same machine with similar, well-calibrated instruments. The SAE sub-committee did a study of this variation and an example of the same measurement taken by seven different observers is shown in Table VIII. It is assumed that this variation occurs because the noise level is fluctuating and different observers tend to estimate the average value of an unsteady meter needle in different ways.

TABLE VIII. VARIATIONS IN NOISE LEVELS OBSERVED AT 50 FT

Observer	1	2	3	4	5	6	7	Average
Level, dB(A)	70	71	71	71.5	71	72	71.5	71.1

Surface Variations

Large variations in noise level, as much as ±3 dB(A), have been found to arise from different surfaces used for the measurement. A hard surface will give a higher level than a soft one, Fortunately, this variation has been removed in the proposed SAE code of practice which specifies a Tartan Turf surface (Appendix B).

Combining the variations due to sample and observer , we get a total maximum variation of ±2.5 dB(A). Thus, on occasion a given model of machine may be measured 2.5 dB(A) louder or quieter than its average level.

4. NOISE CONTROL

The most commonly used lawnmower is the rotary gasoline type. It thus represents a "standard" mower in terms of performance, cost, and noise. Other types of mowers may be quieter. For example, a battery-powered riding mower is about 63 dB(A) at 50 ft, and a gasoline-powered walk-behind reel mower is about 64 dB(A) at 50 ft. Both comply with the 1978 Chicago ordinance level. However, they both have significant cost and performance penalties. Battery-powered riding mowers initially cost 35% more than gasoline-powered riding mowers and they run for only 45 minutes on one charge. A gasoline-powered walk-behind reel mower costs 50% more than an ordinary rotary and 10% more than a self-propelled rotary mower. (A reel mower is always self-propelled to ensure the right 'bite' of the blade.) Further, a reel mower does not cut long grass or uneven lawns well and is difficult to manage in confined spaces.

The cost of quieting a mower is nearly independent of its total cost, which is determined by luxuries like self-propulsion. Thus, the cost of quieting a cheap mower is relatively much higher.

4.1 Noise Sources

The four main noise sources of gasoline-powered rotary mowers are illustrated in Fig. 6.

Mechanical Vibrations

The engine causes the structure of the mower to vibrate and the vibrating structure in turn radiates sound. Vibrations are not generally important with walk-behind mowers, because the deck is relatively stiff, but they do produce substantial noise on

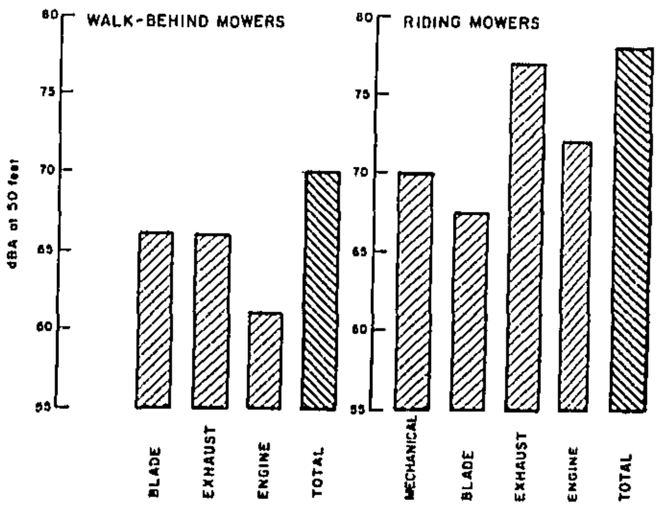


FIG. 6. SOURCES OF NOISE

riding mowers where there are more mechanical linkages to rattle and a larger structure. No significant noise difference has been found between pressed steel and cast magnesium decks.

Blade

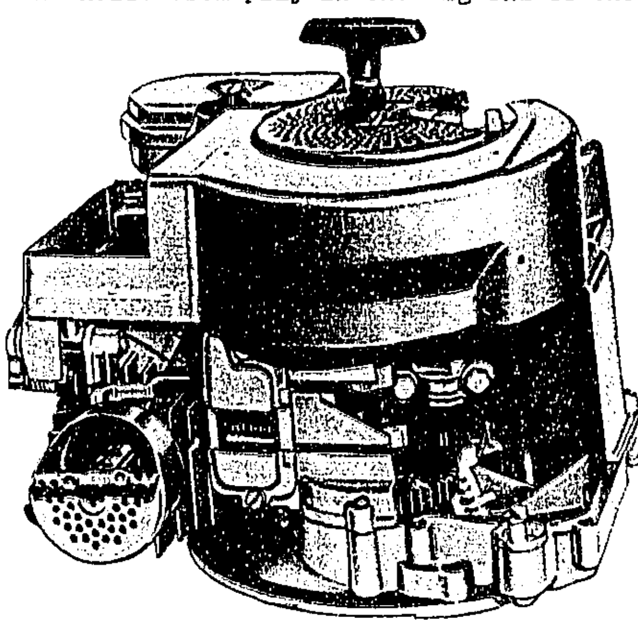
The blade on a rotary mower serves three functions: (1) to lift the grass in preparation for cutting, (2) to cut it, and (3) to lift the cuttings into a bag or distribute them. The blade moves air, thereby generating noise. On a walk-behind mower, the blade is one of the most important noise sources. There are five main mechanisms whereby the blade produces its noise. In the 100 to 500 Hz frequency range, these mechanisms are steady blade lift and drag, blade thickness, fluctuating blade lift and drag due to housing, and fluctuating blade lift and drag due to vortex shed from a preceding blade. In the 500 to 2000 Hz frequency range edge noise due to turbulence shed from the trailing edge of the blade is dominant.

Exhaust

Exhaust noise arises from the pulse of exhaust gas emitted each time the engine fires. This source is important because at the present time small engines are not very well muffled.

Engine

Engine noise, in addition to exhaust noise, includes intake noise, casing noise, cooling fan noise, valve noise, piston slap, and noise from play in the big-end of the connecting rod.



CUT-AWAY VIEW OF BRIGGS AND STRATTON 3-1/2 hp LAWN MOWER ENGINE

(REPRODUCED BY COURTESY OF BRIGGS AND STRATTON)

4.2 Definition of Manufacturer's Cost

The costs of quieting quoted here are the manufacturer's costs of buying the item. Cost is not the same as f.o.b. price, which includes the manufacturer's overhead and profit. The f.o.b. price may be typically 50% more than the cost, but this percentage will vary.

In estimating the cost, a reasonably large production is assumed so that the manufacturer is not incurring the costs of small-scale production. Thus, when we are including the tooling costs for the design changes ($250,000), it is assumed that these costs are spread over a fairly substantial number of units, namely 250,000 units for 5 years, giving a cost of 20¢ per unit. If a manufacturer produces fewer units, then the costs will be higher. All prices quoted are at the 1973 level.

4.3 Noise Reduction by Component Interchange

It is possible to reduce typical noise levels of mowers by fitting currently available items to the machines. Two levels of effort are possible with this approach. The sound levels quoted here are the median levels for the machines.

Level 1 - Muffler

Use best muffler available. Current engine exhaust mufflers can reduce exhaust noise to a point where it is no longer a major noise source. The effect on noise levels is shown in Fig. 7. It can be seen that there is about a 2.5 dB(A) reduction in total noise level. The cost of fitting the best muffler is about 80¢ more than the average muffler for a walk-behind mower and $4.00 for a riding mower.

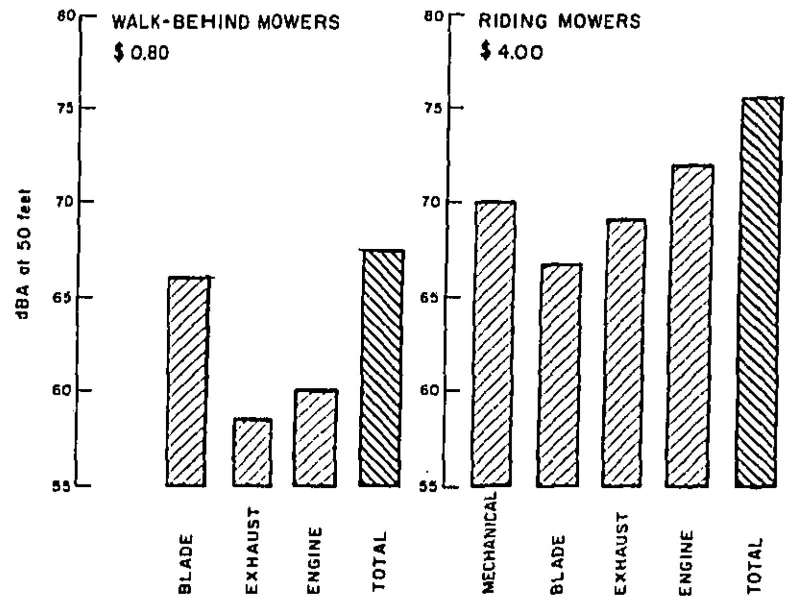


FIG. 7. LEVEL 1: BEST MUFFLERS CURRENTLY AVAILABLE.

Level 2 — Muffler and Slow Engine

Use best muffler and reduce engine speed. Most walk-behind mower engines now run at 3300 rpm and riding mower engines at 3600 rpm. A significant noise reduction can be obtained by slowing the engine to 2900 rpm or so. Doing so reduces the frequency of the engine noise and slows the blade so that it, too, is quieter. However, at the same time grass cutting performance is degraded. In the case of riding mowers, the loss in power from the slower engine is probably acceptable. In the case of a walk-behind mower with its smaller engine, the loss in power is unacceptable and the manufacturer must switch to the next larger engine made. Even so, the larger engine can also be quieted and the result is still a quieter mower. The results are shown in Fig. 8.

Level 2 quieting reduces noise about 4.5 dB(A) on the walk-behind mower and 4 dB(A) on the riding mower. The net cost is about $4.40 on the walk-behind and $4.00 on the riding mower. There is also a performance penalty of about 10% in grass cutting ability. This noise reduction is the most that can be achieved with currently available components. Any further noise reduction requires special design and noise control engineering.

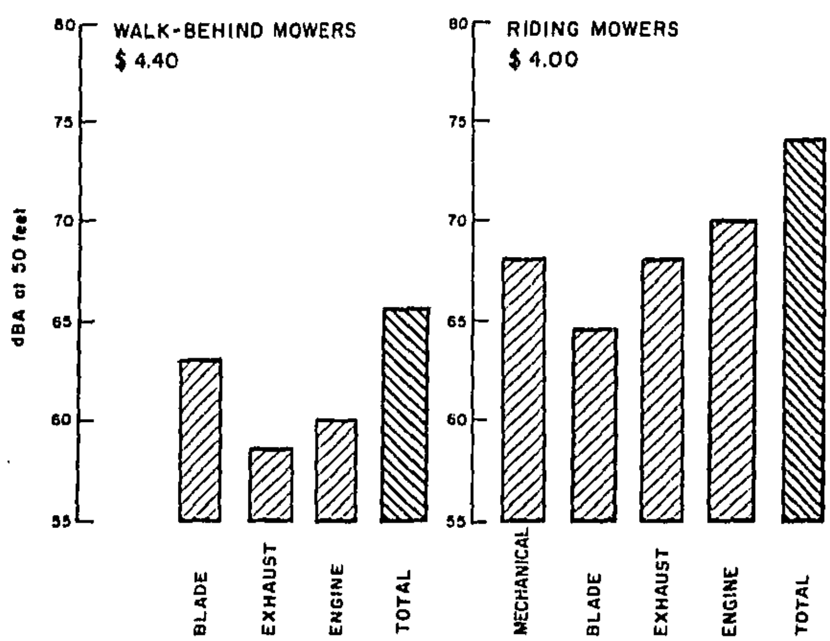


FIG. 8. LEVEL 2: SLOWER ENGINE.

4.4 Noise Reduction by Noise Control Engineering

Two areas of development are clearly required if the noise of mowers is to be reduced below that of Level 2: a "quiet blade" and engine enclosures.

In 1959, W.C. Sperry and G.J. Sanders [8] of the Armour Research Foundation undertook an examination of the blade noise problem for Briggs and Stratton, a leading manufacturer of small engines. They proposed a quiet blade which was "swept forward" and had a sharpened trailing edge. A blade noise reduction of about 7 dB(A) was produced, but whether this reduction could still be achieved with the high lift blades currently being used to bag grass is open to question. The Toro Company used a sickle blade, which was swept forward, on their whirlwind mowers between 1963 and 1970 but have now discontinued it.

Further research is required to determine which of the five blade-noise mechanisms mentioned in Sec. 4.1 is the most important and how it can be quieted. Some manufacturers have proprietary ideas as to how blade noise can be reduced. A conservative estimate is that redesign of the blade and housing can achieve 5 dB(A) of noise reduction at a cost of $2.00 for walk-behind mowers and $4.00 for riding mowers.

Certain manufacturers are currently investigating various engine enclosures. Fully enclosing the engine prevents the noise from escaping, but at the same time blocks cooling air from entering and leaving the enclosure. A partial enclosure surrounding the cylinder head on a walk-behind mower solves the air problem but does not provide as much quieting. It costs about $1.70. A full engine enclosure with provisions for air flow costs about

$3.70. On a riding mower, a partial enclosure consisting of a simple box around the engine costs about $8.00. A full engine enclosure complete with acoustic lining costs about $20.00.

Other noise control approaches include reducing the tolerances on manufacturing the engine so that there is less valve noise, piston slap, and connecting rod noise as well as soft-mounting the engine to reduce the vibrations transmitted to the mower. This latter measure is very important on riding mowers.

In the following paragraphs, we describe the results of different levels of noise control effort based on the treatments described above. The sound levels quoted in this section are the median levels for the machines.

Level 3 — Muffler and Quiet Blade

We retain the muffler used to achieve Level 1 and add a quiet blade. On walk-behind mowers, we achieve a reduction of 5.5 dB(A) for a cost of $2.80. On riding mowers, the improvement over Level 1 is not significant, because blade noise is not a major source (see Fig. 9).

Level 4 — Muffler, Slow Engine, and Quiet Blade

We now fit a quiet blade to a machine which already has a good muffler and slower engine. The improvement is not very great, since blade noise is already low because of the slow engine. We get a reduction of 6.5 dB(A) for $6.40 on walk-behind mowers. The blade noise on riding mowers is also very low. The levels are shown in Fig. 10. A leading manufacturer expects to be marketing a machine with this state of acoustic treatment in the fall of 1973.

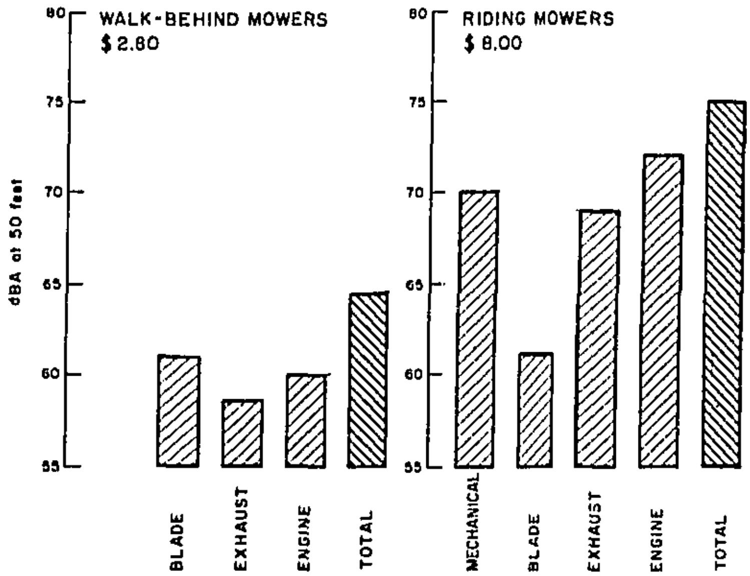


FIG. 9. LEVEL 3: MUFFLER AND QUIET BLADE.

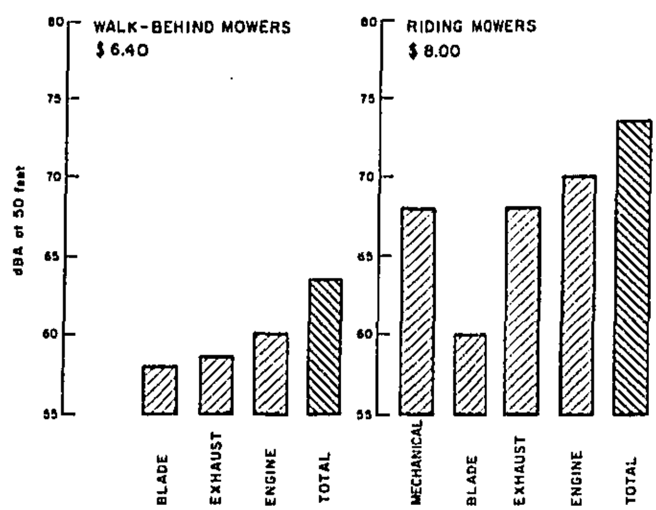


FIG. 10. LEVEL 4: SLOWER ENGINE AND QUIET BLADE.

Level 5 — Muffler, Slow Engine, and Partial Enclosure

At this level, engine noise is reduced by a partial enclosure and the engine tolerances on walk-behind mowers are lowered. Blade noise now dominates on the walk-behind mower which means that we get only a 5.5 dB(A) reduction for \$7.90. With a riding mower we get a 6.5 dB(A) reduction for \$12.00 (see Fig. 11).

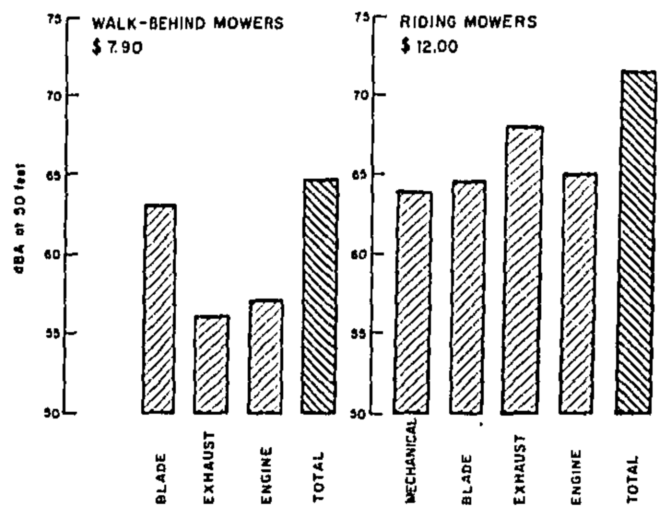


FIG. 11. LEVEL 5: PARTIAL ENCLOSURE.

Level 6 — Muffler, Slow Engine, Partial Enclosure, and Quiet Blade

The treatment is the same as Level 5 with the addition of a quiet blade. We now have an 8.5 dB(A) reduction on walk-behind mowers for \$9.90, but on riding mowers the improvement over Level 5 is not significant. The levels are shown in Fig. 12.

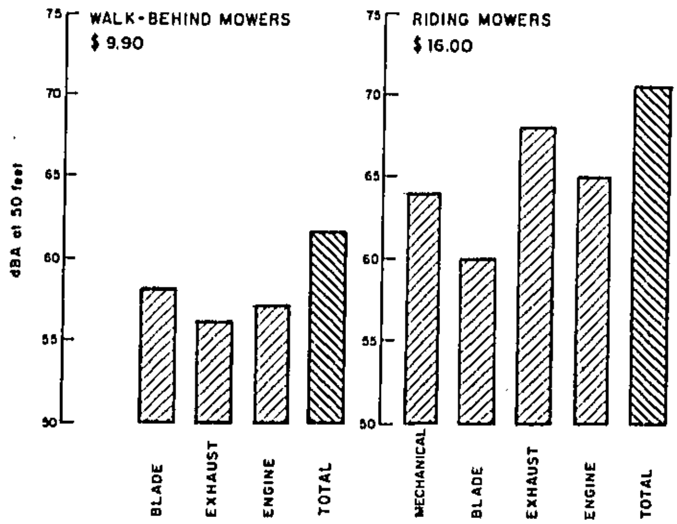


FIG. 12. LEVEL 6: PARTIAL ENCLOSURE AND QUIET BLADE.

Level 7 — Muffler, Slow Engine, Full Enclosure, and Soft Mounting

Level 7 represents the full acoustic treatment possible without considering the blade. Now for both walk-behind and riding mowers, the blade noise dominates. For walk-behind mowers, we have a noise reduction of 6 dB(A) for $9.60 and for riding mowers, 10 dB(A) for $28.00. The levels are shown in Fig. 13.

Level 8 — Muffler, Slow Engine, Full Enclosure, Soft Mounting and Quiet Blade

Since blade noise dominates in Level 7, adding a quieter blade has a significant effect. We achieve a 10 dB(A) reduction for $11.60 on walk-behind mowers and a 12 dB(A) reduction for $32.00 on riding mowers. The levels are given in Fig. 14.

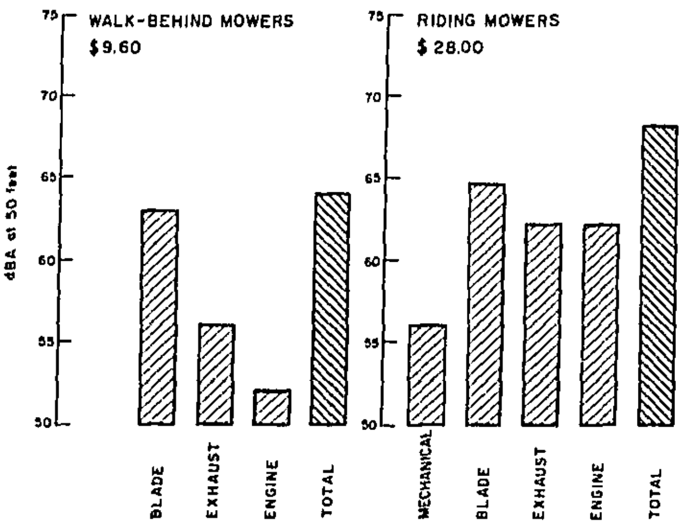


FIG. 13. LEVEL 7: FULL ENCLOSURE.

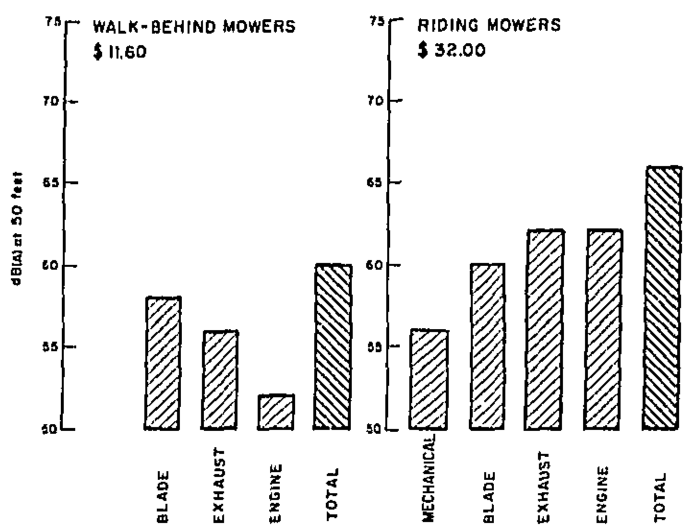


FIG. 14. LEVEL 8: FULL ENCLOSURE AND QUIET BLADE.

Level 8 represents the state of the art for the near future until a new significant research contribution is made to the problem. The costs are of the same magnitude as those of the safety features required by OPEI, about \$3.00 for walk-behind and \$7.00 for riding mowers.

Any further substantial reduction would require a fundamental look at the lawn mower noise sources and considerable innovation. The concept of the engine and rotary blade would have to be reassessed and a completely new design or means of cutting grass devised. Just what could be done is not currently known.

5. CONCLUSIONS

The results of the previous section, expressed in terms of sound level at 50 ft vs cost to the manufacturer, are presented in Fig. 15 for walk-behind mowers and in Fig. 16 for riding mowers.

Note that slowing down the engine results in a performance penalty of about 10% in mowing speed. However, note also that the costs and performance penalties of going to electric-powered or reel mowers are still greater than those for quieting gasoline-powered rotary mowers.

Riding mowers tend to be noisier because they are larger and must meet more power demands than walk-behind mowers. Further, riding motors tend to be used on large lawns where they are not very close to other homes or buildings. Thus, in view of the high cost involved in quieting them, there is a good case for setting different levels for riding and walk-behind mowers.

Given below is a list of the costs and time scales to meet three different levels of quieting: (1) the best levels currently achieved by any manufacturer, (2) the best level which could possibly be achieved with current technology, and (3) an intermediate level. The sound levels quoted in this section are the maximum "not to exceed" levels where an allowance for manufacturing tolerances has been included.

MINIMUM STANDARD — BEST CURRENT LEVELS

Walk-Behind Mowers 68 dB(A)

This requires fitting the best available muffler and slowing the engine 200 rpm.

Cost	Per Unit	= 80¢
	Tooling	= None
Lead Time		= 9 months

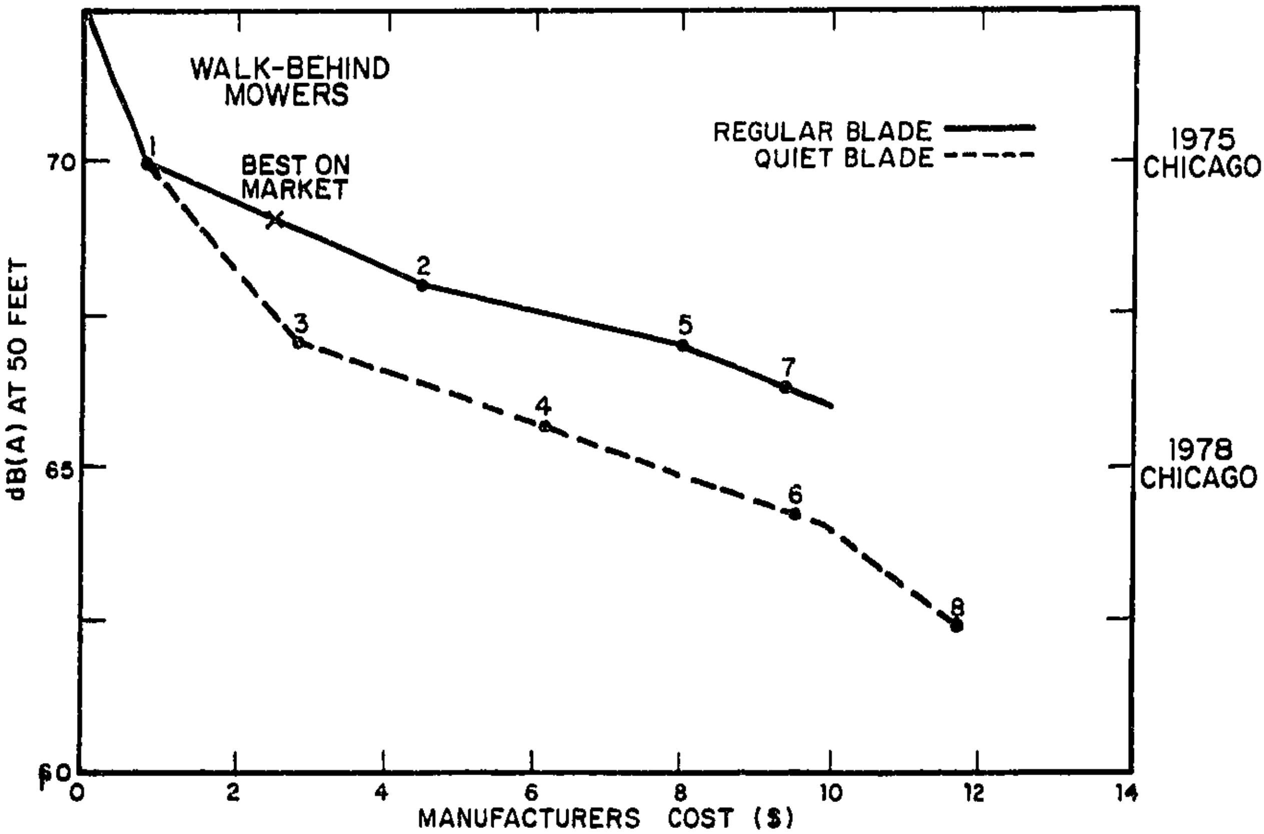


FIG. 15. NOISE REDUCTION COSTS OF WALK-BEHIND MOWERS

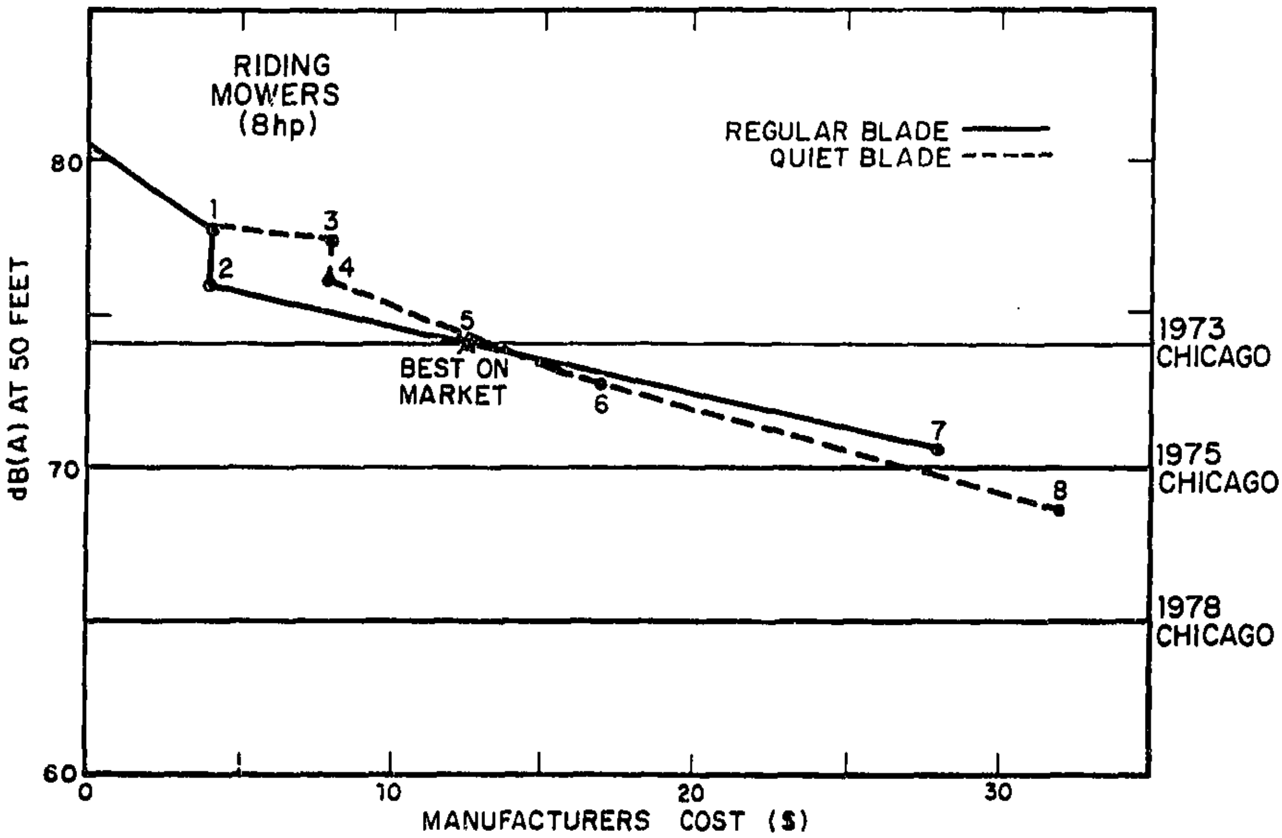


FIG. 16. NOISE REDUCTION COSTS OF RIDING MOWERS.

Riding Mowers 74 dB(A)

This requires fitting the best available muffler, slowing engine to 3,400 rpm and fitting a cover around the engine, making provision for cooling air.

Cost	Per Unit	= $12.00
	Tooling	= $250,000 (some manufacturers have already incurred this cost)
Lead Time		= 1 Jan 1975 (since most manufacturers have already started)

INTERMEDIATE STANDARD

Walk-Behind Mowers 66dB(A)

This is achieved by the best muffler, slowing engine 500 rpm, and fitting an acoustic enclosure around it. An alternate way of achieving this standard would be to incorporate a quiet blade on the mower instead of enclosing the engine. However, only certain of the larger companies would have the capability to do this.

Cost	Per Unit	= $9.60 (Standard Manufacturer)
		= $6.40 (High Technology Approach)
	Tooling	= $250,000
Lead Time		= 2 1/2 years (One leading manufacturer will achieve this level in his 1974 model.)

Riding Mowers 70dB(A)

This essentially requires the best muffler, an engine slowed to 3,000 rpm, and an acoustic enclosure around the engine.

Cost	Per Unit	= $28.00
	Tooling	= $250,000
Lead Time		= 2 1/2 years

STRICTEST STANDARD

Walk-Behind Mower 62dB(A)

This requires the best muffler available, slowing the engine 500 rpm, an acoustic engine enclosure, and a quiet blade.

Cost	Per Unit	= $11.80
	Tooling	= $250,000
Lead Time		= 3 years (2 years for a leading manufacturer who now has capability)

Riding Mowers 68dB(A)

This requires the best muffler available, engine speed reduced to 3,000 rpm, acoustic enclosure around engine, and a quiet blade.

Cost	Per Unit	= $32.00
	Tooling	= $250,000
Lead Time		= 3 years

REFERENCES

1. National Industrial Pollution Control Council - Sub-Council Report, "Leisure Time Product Noise", May 1971.

2. W.C. Sperry and G.J. Sanders, "Quiet Blades for 18-in. Rotary Type Power Lawn Mowers", *Noise Control*, 26 May 1959.

APPENDIX A

LIST OF MANUFACTURERS, ASSOCIATIONS AND RETAILERS CONTACTED

Company: AMF Inc.
Address: 695 Hope Street; Stanford, Conn. 06907
Telephone Number:
Person Contacted - Position: Mr. J.A. Cosh (Director)

Company: Ariens Company
Address: 655 W. Ryan Street; Brillion Wisconsin 54110
Telephone Number: (414)-756-2141
Person Contacted - Position: Michael Ariens (President)

Company: Atlas Tool & Mfg. Co.
Address: 5151 Natural Bridge; St. Louis, Mo. 63115
Telephone Number: (314)-385-7800
Person Contacted - Position:

Company: Black and Decker Mfg. Co.
Address: 701 East Joppa Road; Towson, Maryland 21204
Telephone Number: (301)-828-3900
Person Contacted - Position: Ray Duran (Engr); Leonard Bloom (Director Patents and Licenses) x3240

Company: Boise Cascade Corp.; Power Systems Division
Address: P.O. Box 809; Springfield, Ohio
Telephone Number: (513)-325-0494
Person Contacted - Position:

Company: Briggs and Stratton Corp.
Address: 3300 North 124th Street; Wauwatosa, Wisconsin 53201
Telephone Number: (414)-461-1212
Person Contacted - Position: Douglas Gordon; Joseph R. Harkness (VP Research); Leo Lechtenburg (VP)

Company: Bolens Division (FMC Corp.)
Address: 275 Park Street; Port Washington, Wisconsin 53074
Telephone Number: (414)-284-5521
Person Contacted - Position: Mr. David Philips

Company: Cooper Mfg. Co.
Address: 411 South First Avenue; Marshalltown, Iowa 50158
Telephone Number: (515)-752-5409
Person Contacted - Position: Mr. C.H. Cooper (VP Mower Division)

Company: Deere & Co.
Address: John Deere Road; Moline, Illinois 61265
Telephone Number: (414)-485-4411
Person Contacted - Position: Dick Mylie

Company: General Leisure Products Corp.; (Sub. of Arctic Enterprises)
Address: P.O. Box 635; Thief River Falls, Minnesota 56701
Telephone Number: (218)-681-1147
Person Contacted - Position: Mr. Dennis Brown

Company: Gibson Bros. Co.
Address: Plymouth, Wisconsin 53073
Telephone Number: (414)-893-1011
Person Contacted - Postion: E.W. Enters (VP Engineering)

Company: Hahn Division (Kearney-National Inc.)
Address: 1625 North Garvin St., Evansville, Indiana 47717
Telephone Number: (812)-424-0931
Person Contacted - Position: Charles Sorenson (Director of Engineering)

Company: Homelite (Subs Textron)
Address: 70 Riverdale Avenue, Port Chester, New York 10573
Telephone Number: (914)-939-3400
Person Contacted - Position: Mr. Burke

Company: Huffman Mfg. Co.
Address: Richmond, Indiana
Telephone Number: (317)-966-0555
Person Contacted - Position: Dan Hart (Product Engineer)

Company: International Harvester
Address: 401 North Michigan Avenue; Chicago, Illinois 60611
Telephone Number: (312)-527-0200
Person Contacted - Position: Roger Ringham (VP Environmental Quality)
Bennett (Hinsdale)-(312)-325-1700 x 496

Company: Jacobsen Mfg. Co.; (Subs. Allegheny Ludlum)
Address: 1721 Pachard Avenue; Racine, Wisconsin 53403
Telephone Number: (414)-637-6711
Person Contacted - Position: Paul Clymer

Company: King O Lawn Inc.
Address: 10127 Adella Avenue; South Gate, California 90280
Telephone Number: (213)-567-2107
Person Contacted - Position: Leonard A. Fass (VP)

Company: Locke Mfg. Div. (Stellar Industries)
Address: 1085 Connecticut Avenue; Bridgeport, Conn. 06607
Telephone Number: (203)-333-3157
Person Contacted - Position: George I. Wiese (VP/GM)

Company: M.T.D. Products Inc.
Address: 5389 West 130th Street; Cleveland, Ohio 44111
Telephone Number: (216)-225-7711
Person Contacted - Position: Don Thon

Company: McDonough Power Equipment Inc.; (Subs. Fuqua Industries Inc.)
Address: McDonough, Georgia 30253
Telephone Number: (404)-957-3916
Person Contacted - Position: H. Jackson (Chief Engineer)

Company: Montgomery Wards
Address: 619 West Chicago Avenue; Chicago, Illinois 60607
Telephone Number:
Person Contacted - Position: Mr. Gould (Chief Buyer, Lawn Equipment)

Company: Murray Ohio Mfg. Co.
Address: 635 Thompson Lane; Nashville, Tennessee 37204
Telephone Number: (615)-834-4500
Person Contacted - Position: D.L. Pitman (VP Engineer)

Company: Nelson Muffler Corp.
Address: Stoughton, Wisconsin 53589
Telephone Number: (608)-873-6641
Person Contacted - Position: S.L. Gjermo (Sales Engineer)

Company: Outboard Marine; Evinrude Works

Address: Milwaukee, Wisconsin

Telephone Number: (414)-445-0643

Person Contacted - Position: Richard Lincoln (Manager, Environmental Engineering) x204

Company: Outdoor Power Equipment Institute Inc.

Address: 734 15th N.W.; Washington, D.C.

Telephone Number: (202)-737-6510

Person Contacted - Position: Dennis Dicks (Executive Director)

Company: J.C. Penney

Address: 1301 Avenue of the Americas; New York, N.Y. 10019

Telephone Number:

Person Contacted - Position: Mr. Bunker (Chief Buyer Lawn Equipment)

Company: Roper Corp.

Address: Newark, Ohio

Telephone Number: (614)-345-9881

Person Contacted - Position: Don Gobin

Company: The O.M. Scott and Sons Co. (Subs. ITT)

Address: 333 West Maple Street; Marysville, Ohio 43040

Telephone Number: (513)-642-6015

Person Contacted - Position: Mr. Amerine

Company: Sears Roebuck

Address: 925 South Homan Avenue; Chicago, Illinois 60607

Telephone Number: (312)-265-5165

Person Contacted - Position: Mr. Hillbrand (Senior Buyer for Lawn Mowers) Dept. 609

Company: Simplicity Mfg. Co. Inc.; (Subs. Allis-Chalmers)
Address: 500 West Spring St., Port Washington, Wisconsin 53074
Telephone Number: (414)-284-5535
Person Contacted - Position: Igor Kamlukin (VP Engineer)

Company: Sunbeam Corp.; Research and Development Division
Address: South Carolina
Telephone Number: (803)-435-8441
Person Contacted - Position: John Robinson

Company: Tecumseh Products Co.; Taylor Products Division
Address: Elkhart, Indiana 46512
Telephone Number: (219)-522-4187
Person Contacted - Position: F. Melkus (Sales Director); B. Mann (Sales Engineer)

Company: Tecumseh Products Co.; Lawson Emgines Division
Address: New Hollstein, Wisconsin
Telephone Number: (414)-989-5711
Person Contacted - Position: William Hermanson, Dr. Otto Reiger (R&D Centre)

Company: Toro Company
Address: 8111 Lyndale Avenue, South; Minneapolis, Minnesota 55420
Telephone Number: (612)-888-8801
Person Contacted - Position: Robert Witt

Company: Wood Brothers Mfg. Co.; (Subs. Hesston Corp.)
Address: Rte. 2; Oregon, Illinois 61061
Telephone Number: (815)-732-6156
Person Contacted - Position: Mr. McAmse

Company: United States Testing Co., Inc.; Research Division
Address: 1415 Park Avenue, Hoboken, New Jersey
Telephone Number: (201)-792-2400
Person Contacted - Position: Mr. Yoder

Company: Yazoo Mfg. Co.
Address: P.O. Box 4207, Jackson, Mississippi
Telephone Number: (601)-368-6421
Person Contacted - Position:

APPENDIX B

EXTERIOR SOUND LEVEL MEASUREMENT PROCEDURE FOR SMALL ENGINE POWERED EQUIPMENT -

SAE Recommended Practice

Scope This SAE Recommended Practice establishes the instrumentation and procedure to be used in measuring the maximum exterior sound level for engine powered equipment under 20 rated brake horsepower. It is not intended to include equipment designed primarily for operation on highways or within factories and buildings, or vehicles such as motorcycles snowmobiles and pleasure motor boats that are covered by other SAE Standards.

This SAE Recommended Practice may also be used when measuring the maximum exterior sound level on similar equipment powered by electricity or other power sources.

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

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

2.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or a graphic level recorder or indicating meter providing the system meets the requirements of SAE Recommended Practice J184.

2.3 A sound level calibrator (see Paragraph 4.2.4).

2.4 The microphone shall be used with an acceptable windscreen. To be acceptable, the screen must not affect the microphone response more than $\pm$ 1 dB for frequencies from 20 to 4000 HZ or $\pm$ 1½ dB for frequencies from 4000 to 10,000 HZ (see Paragraph 4.3).

2.5 An anemometer or other device for measurement of ambient wind speed and direction.

2.6 An engine speed indicator.

2.7 A thermometer for measurement of ambient temperature.

Procedure

3.1 Test Site The test area shall consist of a flat open space free of any large reflecting surfaces such as a signboard, building, or hillside located for a minimum distance of 100 feet (30.4 metres) of the measurement zone.

3.1.1 The minimum dimensions of the measurement zone are defined as a path of travel 4 feet (1.2 metres) wide by 46 feet (14 metres) long plus an adjacent triangular area having the base along the edge of the path of travel and the apex 23 feet (7 metres) from the midpoint of the base. (See figure 1).

3.1.2 The surface of the measurement zone shall be: Synthetic turf surface mounted to 3/4" exterior plywood or ½" minimum thickness marine plywood with suitable adhesive. Turf to be ½" pile height, 60 denier nylon 6 fiber, approximately 32 oz/sq. yd. on polypropylene backing approximately 5 oz/sq. yd.

Acoustical properties after mounting on plywood shall be:

HZ	Sound Absorption Coefficient
125	.04 - .06
250	.09 - .12
500	.20 - .28
1000	.30 - .32
2000	.40 - .46
4000	.46 - .62

3.1.3 The observer with the meter shall be at least 10 feet (3.0 metres) from the microphone. Not more than one person other than the observer reading the meter, shall be within 50 ft (15.2 m) of the vehicle path or instrumentation, and that person shall be directly behind the observer who is reading the meter, on a line through the microphone and the observer.

3.1.4 The ambient sound level (including wind effects) due to sources other than the equipment being measured, shall be at least 10 dB(A) lower than the level of the equipment being measured.

Equipment Operation

3.2.1 Operate the equipment at the combination of load and speed which produces the maximum sound level without violating the manufacturer's operation specifications.

3.2.2 Recommended Loading Techniques:

3.2.2.1 Walk-behind Mowing Equipment:

Test as mobile equipment (3.3.5). Run engine or motor at the mower manufacturer's maximum specified speed. Set blade at closest available setting to 2" (50.8 mm) cutting height. Engage blade and self propelling mechanism if available. Additional loading mechanism not deemed necessary.

3.2.2.2 Riding, Mowing Equipment:

Test as mobile equipment (3.3.5). Run engine or motor at the mower manufacturer's specified maximum speed. Set blades at closest available setting to 2" (50.8 mm) cutting height and engage blades. Obtain the maximum sound level with a brake load and/or towing a load (see Paragraph 3.2.3).

3.2.2.3 Walk-behind Snow Blowers and Tillers:

Test as equipment which is not traveling (3.3.4). Set no load speed of engine at manufacturer's specified maximum setting, engage all mechanism other than propelling, load equipment output shaft with a brake to obtain maximum sound level (see Paragraph 3.2.3).

3.3.3.4 Chain Saws

Test as equipment which is not traveling (3.3.4). Position the equipment 2 feet (.6 metres) above the test surface and operate to produce maximum sound level. Loading by cutting a log may be required.

3.2.2.5 Garden Tractors with Attachments other than Mowers:

Test as (3.3.6). Run engine(s) or motor(s) at the manufacturer's specified maximum speed. With attachments engaged, obtain the maximum sound level with a brake load and/or tow load. (see Paragraph 3.2.3).

3.2.2.6 Miscellaneous Equipment

Run engine(s) or motor(s) at the manufacturer's specified maximum speed. With equipment engaged, obtain the maximum sound level with a brake load, tow load or other method of loading. (see Paragraph 3.2.3).

3.2.3 Auxiliary Loading

The sound level of the auxiliary load shall be at least 10 dB(A) less than the equipment being measured. The presence of the auxiliary load shall not affect the sound radiated to the microphone.

3.3 Measurements

3.3.1 The microphone shall be located at the apex of the triangular test area at a height of 4 feet (1.2 metres) above the ground plane.

3.3.2 The sound level meter shall be set for "slow" response and for the A-weighting network.

3.3.3 The ambient wind speed and direction relative to source and microphone, ambient temperature , and ambient dB(A) sound level shall be measured and recorded.

3.3.4 For equipment which is not traveling, test as follows: With operator in normal position, orient equipment to obtain maximum sound level. Record the highest repeatable sound level obtainable at 23 feet (7 metres) from the nearest surface of the equipment. Operate the equipment as specified in section 3.2.

3.3.5 For mobile equipment, take measurements at 23 feet (7 metres) normal to a major side surface along a path of straight line travel. Operate the equipment as specified in section 3.2. Rotary mower chute extensions are not to be considered a major side surface.

The applicable reading for this test condition will be the highest repeatable sound level obtained from the equipment as it moves along the line of travel. The equipment shall run at least twice in each direction or until the number of readings equals or exceeds the range of decibels of the A-weighted sound level obtained. The highest repeatable dB(A) reading shall be reported as the sound level of the particular equipment for this test condition.

3.3.6 For the equipment that can be operated mobile and not traveling, test under both specifications 3.3.4 and 3.3.5. The highest sound level results shall be recorded.

3.3.7 To convert the sound level readings obtained at 23 feet (7 metres) to 50 feet (15.2 metres) readings, subtract 7 dB(A) from the 23 feet (7 metres) readings

4. General Comments

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

4.2 Proper usage 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:

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

4.2.2 The effects of ambient weather conditions on the performance of all instruments (e.g. temperature, humidity, and barometric pressure). Instrumentation can be influenced by low temperature and caution should be exercised.

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

4.2.4 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.

4.3 It is recommended that measurements be made only when wind velocity is below 12 mph (19.3 km/h).

<u>References</u>

Suggested reference material is as follows:

1.	ANS S1.1 - 1960	Acoustical Terminology
2.	ANS S1.13 - 1971	Methods of Measurement of Sound Pressure Levels
3.	ANS S1.4 - 1971	Specification for Sound Level Meters
4.	SAE J184	Qualifying a Sound Data Aquisition System

(Applications for copies of documents listed under 1, 2 and 3 should be addressed to: American National Standards Institute, Inc.
1430 Broadway
New York, N. Y. 10018)

DG:ht

The following sound levels, when measured in accord with the test procedure described above, represent current engineering practice as of January, 1973, on the following types of equipment:

		dB(A)	
	EQUIPMENT	23 Feet	50 Feet
1.	Rotary Mowers, walk-behind	77	70
2.	All Riding Mowers	82	75
3.	Snow Blowers and Tillers	85	78
4.	Chain Saws	93	86

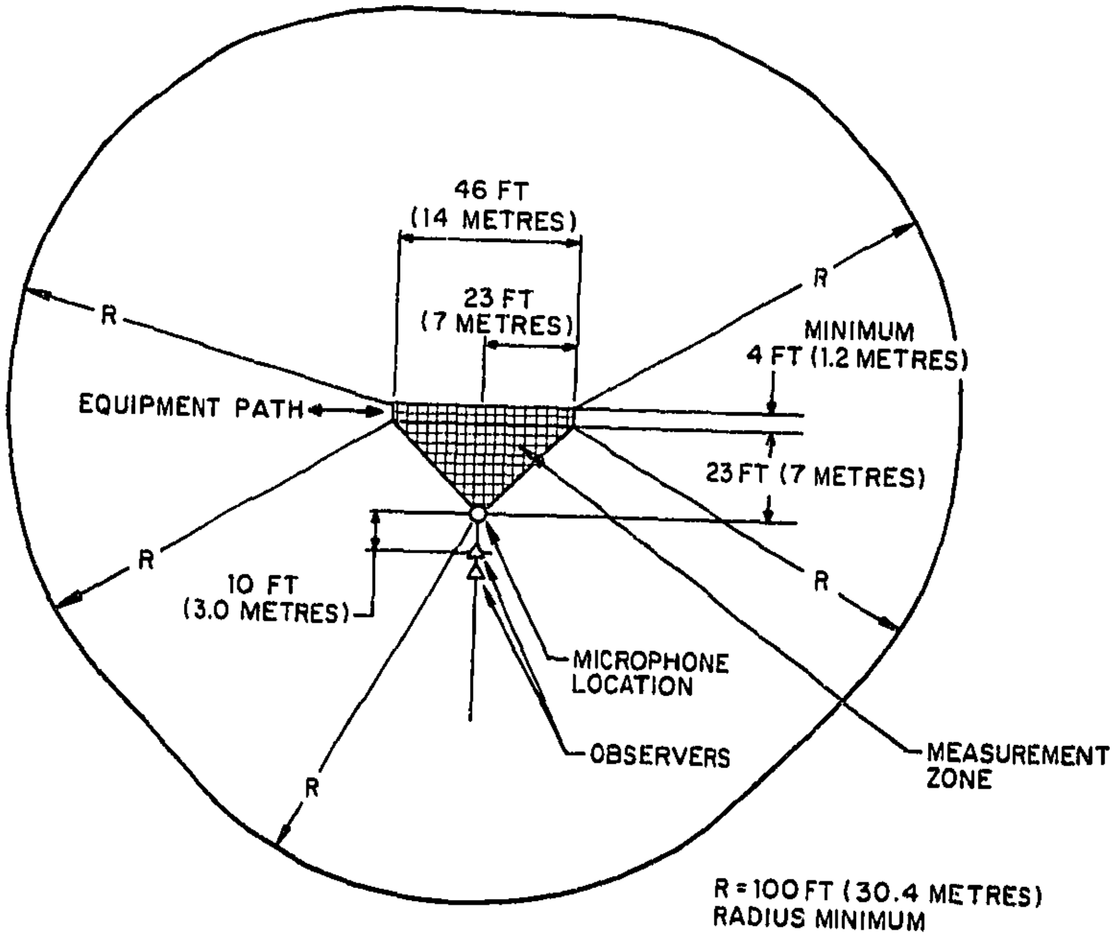


FIG. B.1. TEST SITE.

RATIONALE FOR SPECIFIC ITEMS IN THE PROPOSED SAE RECOMMENDED PRACTICE

1. <u>Scope</u>

All terrain vehicles (ATV's) and Mini-bikes are not included in this procedure.

2. <u>Procedure</u>

3.1 Open space has traditionally been the best test site for measuring sound levels because there are not many indoor test facilities for testing outdoor powered equipment.

3.1.1 The measurement zone has been established using a fixed location for the microphone 23 feet away from the path of the equipment being tested. In the past, SAE procedures have used 50 foot distance as a standard measuring distance. This distance has been used for pass by sound level tests on cars, trucks, and busses. The sound levels of small engine powered equipment are normally 5 to 15 dB(A) lower than the larger equipment using the 50 feet measuring distance. When using a 50 foot measuring distance with small equipment, the effects of wind on the sound propogation can be a significant error in the test measurements.

On most small engine powered equipment, the source of the sound is very close to an absorptive ground surface and having a low grazing angle between the sound and this surface. The further the distance is to the measuring meter, the greater the possibility of variation in attenuation between the source and the microphone, especially when measuring over different grasses and different soils and soil conditions (wet versus dry)

Also, a 23 foot measuring distance reduces the size of the test area needed, and it effectively allows higher background sound levels on the test site. A distance of 25 feet was at first considered, but 23 feet (7 metres) was decided upon as being a better distance to measure since 7 metres is used now in many European standards.

The cost of the area of the artificial test surface was also considered in the above decision.

3.1.2 The majority of the equipment to be tested under this recommended practice is in the lawn care equipment category. Sound level tests were made by individual committee members using one mower at many different grass sites. This testing produced differences between sound levels measured on the same equipment of up to 8 dB(A). The three major variables that caused this large deviation are:

1. The variability of the test sites: The grass and sound varies between test sites due to the quality of the grass, the type of ground underneath and also the amount of moisture.

2. Instrumentation variables which include the type of microphones, sound level meters, the calibration, and the actual reading of the instrumentation by the observers.

3. The speed of the equipment, the type of loading, and the number of measurements taken can also affect the final level measurement.

To reduce the variation between measurements on different test sites, due to the differences in the grass and ground surface, the committee decided to consider using an artificial surface to test the equipment on. The committee thus sponsored the conducted three separate field tests: The first test was to compare measurements over grass to measurements over polyurethane foam surface 1½" thick. This foam was donated by the Scott Company. It was their best judgment as being the equivalent absorption of grass surfaces. Because of troubles of running the equipment over the foam surface, and also because electric mowers had much higher readings on this foam surface, it was decided to run a second test using a synthetic turf surface over the vehicle path, but using the urethane foam on the area between the vehicle path and the microphone. This test resulted in good vehicle operation, but we still continued to have higher readings with electric mowers and we also had a lower reading on this material with 2 cycle rotary lawnmowers. A preliminary test was conducted by two members of the committee using the synthetic turf surface over the vehicle path and the entire measuring area between the vehicle and the microphone. This was done as a stationary test, but it showed the best correlation between grass and the synthetic surface of all the tests that were made. In a third field test by eight committee members testing only on synthetic turf, the correlation to the readings made on grass in previous tests was 1.1 dB(A). Not only does this material have good sound level correlation to grass, but it is a very durable surface to run and load the equipment upon.

The other two testing variables, instrumentation and equipment operation have been considered in other parts of this Recommended Practice.

3.2 Equipment Operation

The committee used the same equipment operations wording as in the J952b but we have added a section on "Recommended Loading Techniques" to give guidance to people testing particular pieces of equipment.

In many of the loading techniques, we have recommended using a Tow Load or an auxiliary Brake Load to obtain maximum sound levels. In our field tests, this was found to be a practical way to obtain maximum noise when testing on artificial surfaces, as well as on grass.

3.3.2 Since the type of equipment tested in this Recommended Practice is either stationary or slow moving, the committee feels "slow" response on the sound level meter is a more satisfactory setting.

3.3.4 With a specific measurement zone, it was found that keeping the microphone stationary and orienting the equipment was the most practical way of obtaining maximum sound levels on stationary equipment.

3.3.5 Our committee felt that the applicable reading should be the highest repeatable sound level obtained. Our field test showed that this reading was obtained very consistently and that any averaging of the higher readings would not give the maximum sound level.

3.3.7 Since this Recommended Practice specified a 23 foot or 7 metre measuring distance, it was felt that we should put in a conversion factor to convert to 50 foot readings which would give correlation to existing sound level measurements. The 7 dB(A) correlation factor is the calculated sound level reduction that would occur under ideal conditions between 23 feet and 50 feet.

45 data points comparing 50' to 23' on tests made by our committee members showed an average of 6.9 dB(A) difference between 50' and 23'

16 data points in the third field test produced a 6.99 dB(A) difference between 50' and 23 .

Douglas Gordon
Secretary
3-26-73

DG:ht

APPENDIX C

DRAFT #11

NOISE LEVELS OF CURRENT LAWN MOWER MODELS

DRAFT — MARCH 26, 1973

Lawn Mower Make	Model No	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
1. Lawnboy (Outboard Marine)	3058	100	66	18	3200	OM	3	2	1 1/2	
	5239-B	110	66.5	19	3200	OM	3	2	1 1/2	
	5241	120	65.5	19	3200	OM	3	2	1 1/2	C/D
	5269-B	120	67.5	19	3200	OM	3	2	1 1/2	Catcher
	5271	130	67	19	3200	OM	3	2	1 1/2	C/D, Catcher
	5501	90	64	19	3200	Denso	1	Electric		
	7223	130	65.5	21	3200	OM	3	2	1 1/2	C/D
	7260-B	130	67.5	21	3200	OM	3	2	1 1/2	Catcher
	7262	140	66.5	21	3200	OM	3	2	1 1/2	C/D Catcher
	7262-E	175	67.5	21	3200	OM	3	2	1 1/2	C/D, ES, Catcher
	6254	150	67	21	3200	OM	3	2	1 1/2	Hevi-Duti

C/D – Capacitor Discharge Ignition
ES – Electric Start

DCD – Die Cast Deck
SP – Self Propelled

BS – Briggs & Stratton
T – Tecumseh

Lawn Mower Make	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
Lawnboy (cont)	6276	170	68	21	3200	OM	3	2	1 1/2	Commercial
	8231	180	67.5	21	3200	OM	3	2	1 1/2	SP, Catcher, C/D
	8231-E	220	67.5	21	3200	OM	3	2	1 1/2	ES, SP, Catcher, C/D
2. Toro	16073	100	69.5	19	3400	T	3	4	0	
	16173	120	70.5	21	3400	T	3.5	4	0	
	16273	160	70.5	21	3400	T	3.5	4	0	SP
	19173	130	69.5	19	3400	T	3	4	0	
	19273	170	69.5	19	3400	T	3	4	0	SP
	19373	160	69.5	19	3400	T	3	4	0	ES
	21173	150	70.5	21	3400	T	3.5	4	0	
	21273	190	70.5	21	3400	T	3.5	4	0	SP

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Lawn Mower Make	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
Toro (cont)	21373	220	70.5	21	3400	T	3.5	4	0	ES, SP
	10018	160	65	18	Reel	T		4		SP
	10121 10221	180	65	21	Reel	T		4		SP
3. Sears Roebuck		110	68	20	3400	T	4	4	0	
		140	68.5	20	3400	T	5	4	0	
		180	68.5	22	3400	T	5	4	0	
		75	63	18		Electric	1			
4. Simplicity		120	68	19	3500	BS	3.5	4	0	
		140	72	21	3400	BS	3.5	4	0	
Homelite	See Simplicity		Above							
5. Poloron		52	70	19	3500	BS	3	4	0	Stamped Steel Deck

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Lawn Mower Make	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
6. Black and Decker		50	66.5	18	4000	B&D	.7			Steel Deck
		60	66.5	18	4000	B&D	.7			Steel Deck
		70	72	18	7500	B&D	1			2 Blade
		90	72	18	7500	B&D	1			2 Blade, Catcher
7. General Leisure Products	Lawn Lion	75	68	20	3400	BS	3.5	4	0	Stamped Steel Deck
	Arctic Cat	160	68.5	22	3300	Fichel & Sachs	4	Wankel	1	
8. Jacobsen	11801	150	70	18	Reel	B&S	2	4	0	
	11825	165	65	18	Reel	B&S	2	4	1	
	12104	185	65	21	Reel	B&S	2.5	4	1	
	31902	125		19	3400	B&S	3	4	0	
	32108	140	70	21	3400	B&S	3	4	0	

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Lawn Mower Make	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
	32109	175	70	21	3400	B&S	3	4	0	ES
	42147	180	70	21	3400	B&S	3.5	4	0	SP
	42148	215	70	21	3400	B&S	3.5	4	0	ES, SP
	31901	135		19	3400	Jacob	3	2	0	
	32106	150	70	21	3400	Jacob	3	2	0	
	42143	190	70	21	3400	Jacob	3	2	0	SP
	42144	225	70	21	3400	Jacob	3	2	0	ES, SP
9. Scott	10M3	61	53	18	Reel		Push			
10. International Harvester	See Outboard Marine above									
11. John Deere		See Toro above								
14. M T D	113-670		67	20	3200	BS	3.5	21	1 1/2	

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Lawn Mower Make Riding	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
4. Simplicity	728		77	36	4000	B&S	8	4	0	
10. International Harvester	Cadet 75		76	32	3500	B&S	7	4	0	
11. Huffman		400	73	30	3600	B&S	5	4	0	
		600	82	38	3600	B&S	8	4	0	
12. General Electric	E8M	795	64	36		Electric				
13. John Deere	E90	890	63	34	3200	Electric				
14. M T D	133-445	450	71.5	34	3400	B&S	8	4	4	
1. Lawnboy (Outboard Marine)	9329	535	82	32	3600	B&S	8	4	0	
	9329E	620	82	32	3600	B&S	8	4	0	ES
	9329ES	655	82	32	3600	B&S	8	4	0	ES, Synchrobalanced
Boise Cascade	See Outboard Marine									

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Lawn Mower Make Riding (cont)	Model No.	Price $	Noise Level dB(A)	Cutting Width Inches	Engine Speed rpm	Engine Manu-facturer	Engine hp	Engine No. of Strokes	Treatment Level	Extras
13. John Deere	JD55		70	28	3700	T	5	4	0	
15. Murray Ohio			No load 68.5			B&S	8	4	0	Not Towing

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BIBLIOGRAPHIC DATA SHEET	1. Report No. 550/9-74-011	2.	3. Recipient's Accession No.

4. Title and Subtitle Lawn Mowers: Noise and Cost of Abatement	5. Report Date June 1974
	6.
7. Author(s) M.J. Rudd and E.K. Bender	8. Performing Organization Rept. No.
9. Performing Organization Name and Address Bolt Beranek and Newman Inc.	10. Project/Task/Work Unit No.
	11. Contract/Grant No. 68-01-1539
12. Sponsoring Organization Name and Address Environmental Protection Agency Office of Noise Abatement and Control Crystal Mall #2, 1921 Jefferson Davis Highway Arlington, Virginia 20460	13. Type of Report & Period Covered Final
	14.

15. Supplementary Notes

16. Abstracts

This document contains information useful for the development of noise emission standards for lawn mowers. Topics covered include information on lawn mower construction, noise characteristics of models currently on the market, and noise reduction techniques and costs necessary to achieve specified noise levels.

17. Key Words and Document Analysis. 17a. Descriptors

Lawn mower noise
Lawn mower noise control
Costs of Noise Reduction

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement Limited supply available at ONAC, Arlington, Virginia 20460 Available at NTIS	19. Security Class (This Report) UNCLASSIFIED X	21. No. of Pages
	20. Security Class (This Page) UNCLASSIFIED X	22. Price

FORM NTIS-35 (10-70) USCOMM-DC 40329-P71