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# Field Comparison of Gas-Powered vs. Battery-Powered Equipment for Grounds Maintenance – Hedge Trimming Operations

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## ABSTRACT

**American landscaping workers use a variety of noise-producing equipment and are at a high-risk for hearing loss. Although an effective control strategy is to replace noisy equipment with quieter alternatives, the most common method of hearing loss prevention in the United States is the use of hearing protectors. This reliance on hearing protectors often stems from lack of enforced regulations and the absence of product noise labels.**

**However, one company has successfully implemented a buy quiet program for the task of hedge trimming. This presentation summarizes a field comparison of workers' noise exposure for two hedge-trimming crews: 1) one using gas-powered equipment and 2) the other using battery-powered equipment. Dosimetry and sound level measurements show that the crew using battery-powered equipment had significantly lower noise exposures than the crew using gasoline-powered versions. Furthermore, the management of this hedge-trimming crew provided researchers with information regarding evaluating the feasibility of switching over to battery-powered equipment and their systematic approach to buying quieter equipment.**

**Keywords:** Noise, Buy Quiet, Hearing Loss
**I-INCE Classification of Subject Number:** 56

## 1. INTRODUCTION

### 1.1 Background for this Study

On August 7, 2018, researchers of the Hearing Loss Prevention Team of the NIOSH Hearing Loss Prevention Team visited a Resort Hotel facility. The purpose of this site visit was to obtain preliminary estimates of worker noise dose and equipment sound levels for two

different hedge-trimming crews:  1) one using gasoline-powered equipment and 2) the other using battery-powered equipment.  Each crew consisted of three core workers: two workers trimming hedges with hand-held power tools and one worker using a powered blower to gather the trimmings into a pile (see Figures 1 and 2).  Occasionally a fourth worker was on hand to help collect the trimmings and take them away.


*Figure 1:  Worker using gasoline-powered blower to clear hedge trimmings*

*Figure 2: Worker using gasoline-powered trimmers*

Although the main purpose of the visit was to record data regarding noise levels experienced by the two crews, NIOSH researchers were able to speak at length with representatives from the organization's safety staff and landscape maintenance supervisors and managers. During these discussions it was brought up that limiting noise to hotel guests was a key factor in choosing equipment for landscaping maintenance. Therefore, several sound level meter (SLM) measurements were taken from guest-accessible locations. Additionally, at the request of landscape maintenance management, a short dosimeter sample was taken for the task of using a riding lawn mower.

## 1.2 Occupational Exposure Limits and Health Effects

Noise-induced hearing loss is an irreversible condition that progresses with continued exposure. Although hearing ability tends to decline with age (referred to as presbycusis), exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some other common hearing disorders, it cannot be treated medically. While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it first affects a person's hearing ability in the higher frequencies (4000 or 6000 Hz) and then affects adjacent frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment can be severe enough to permanently affect a person's ability to hear and understand speech under everyday listening conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have higher frequency components which may not be audible for persons with a high frequency noise-induced hearing loss. Additionally, exposure to some chemical substances can create an ototoxic effect. An ototoxic effect exacerbates noise-induced impairments even though the overall noise level may be below the permissible limit.

According to the US Occupational Safety and Health Administration (OSHA), workers exposed to daily noise exposures in excess of 85 dBA (TWA) as an eight-hour time weighted average, based on a 5 dB exchange rate, must be enrolled in a hearing conservation program (HCP). Exposure to work environments in excess of 90 dBA TWA must be lowered through engineering/administrative noise controls. In cases where noise cannot be economically or practically controlled, OSHA regulations allow for workers' hearing to be protected by earmuff or earplug hearing protection devices (OSHA, 2017).

NIOSH establishes Recommended Exposure Limits (REL) for noise based on the best available science and practice that are more protective of worker hearing. The NIOSH REL for noise is 85 decibels, using the A-weighting frequency response over an 8-hour TWA, based on a 3 dB exchange rate. Exposures at or above this level are considered hazardous (NIOSH, 2018).

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## 2. METHODOLOGY

### 2.1 Dosimetry

Dosimetry measurements were taken on landscaping workers to estimate their daily noise dose accumulated over a workshift. Dosimeters were Larson Davis Spark model 706RC. Calibration checks were performed before and after the shift and clocks were synchronized. Dosimeters were set to measure dosage using both the OSHA and NIOSH criteria:

- **NIOSH criteria:** exchange rate: 3 dB; frequency weighting: A; response: slow; threshold level: 80 dBA
- **OSHA criteria:** exchange rate: 5 dB; frequency weighting: A; response: slow; threshold level: 80 dBA

Workers were separated into two groups; one group used battery-powered equipment while the other group use gasoline-powered equipment. In each group, a dosimeter was worn by a worker operating a blower and a worker operating a hedge-trimmer. A short sample (about 5 minutes) was also taken from a gasoline-powered riding mower.

The following data were subsequently reported for each tool using both the NIOSH and OSHA criteria:

- **Dose (%) and TWA (dBA)** – based on the actual amount of time the workers were exposed to noise for the shift
- **Projected Dose (%) and 8-hour TWA (dBA)** – projected values based an eight-hour shift

### 2.2 Sound Level Meter Measurements

Sound level measurements were taken with a Larson-Davis (SLM), Model 831, Serial Number 0001060, and with an Apple iPhone 5S model MD294LL/A equipped with an external microphone (Mic-W model i436). The NIOSH Sound Level Meter (NIOSH SLM) app was used for all measurements made with the iPhone. The NIOSH SLM app has been shown to meet IEC 61672: Part 3, Periodic Testing, when running on an iPhone and used with an external microphone (Celestina et al., 2018). Both SLMs were calibrated at 114 dB before data collection and were re-checked afterwards to ensure the calibration had not drifted while measurements were being taken. Data was time-stamped and the SLM clocks were synchronized before data was logged.

SLM measurements were taken at various locations around the two groups of workers to estimate the levels experienced by both workers and bystanders. To determine distances from the SLM to the noise source, a Leica Disto E7400X Laser Distance Meter was used.

### 2.3 Feedback from Management

The management of the Landscaping Maintenance crews of the property were consulted regarding the use of gasoline-powered and battery-powered tools. At that time they listed several evaluation factors routinely considered when making purchasing decisions and the particular advantages and disadvantages of the models used during the work shift. These comments and best practices are recorded in this report.

## 3. RESULTS

### 3.1 Dosimetry Results

Dosimeters were worn by four workers using the following equipment:

- Battery-powered trimmer – Stihl HLA 65
- Battery-powered blower – Stihl BGA 85
- Gasoline-powered trimmer – Stihl HL 100 K-Z
- Gasoline-powered blower – Stihl BR 550

NIOSH investigators started the dosimeters at about 5:30am and they ran until about 10:30am, at which point the workers were changing tasks and could no longer stay in two separate groups. A typical shift is 8 hours, which includes set-up at the start of the shift, clean-up at the end of the shift, a lunch break and occasional bathroom or water breaks. There were also quiet periods when workers were changing locations, or using manual tools such as a rake or shovel.

Other noise sources: For the first 2 hours of the shift there was a gasoline-powered generator powering lights near the crew using gasoline-powered equipment, and throughout the day another crew of workers was mowing in the vicinity, sometimes within about 10 feet of the landscapers wearing dosimeters.

Results are as follows:

***Table 1. Dosimetry Results – Dose and TWA by Criteria***

| | | OSHA Criteria | | | | NIOSH Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|
| Power Source | Tool | Dose (%) | TWA (dBA) | Projected Dose (%) | 8-hour TWA (dBA) | Dose (%) | TWA (dBA) | Projected Dose (%) | 8-hour TWA (dBA) |
| Battery | Blower | 5 | 72 | 8 | 69 | 30 | 81 | 35 | 79 |
| | Trimmer | 8 | 76 | 13 | 72 | 66 | 85 | 103 | 83 |
| Gas | Blower | 121 | 95 | 194 | 91 | 1449 | 99 | 2318 | 97 |
| | Trimmer | 60 | 90 | 94 | 86 | 330 | 92 | 519 | 90 |

### 3.2 Sound Level Meter Results

Sound levels were measured at various locations around the landscaping workers. These were short-term average readings made over approximately 10 seconds each:

***Table 2: A-weighted sound pressure levels at several locations***

| $LA_{eq}$ (dB) | Noise Source | Position | SLM |
|---|---|---|---|
| 82 | Battery-powered trimmer A | Hearing zone of operator | NIOSH SLM App |
| 79 | Battery-powered trimmer B | Hearing zone of operator | NIOSH SLM App |
| 85 | Battery-powered blower | Hearing zone of operator | NIOSH SLM App |
| 83 | Battery-powered blower | 5-15 feet away | NIOSH SLM App |
| 70 | Battery-powered trimmers (A and B) | About 30-38 feet away | NIOSH SLM App |
| 78 | Gas-powered trimmer | 38 feet away | NIOSH SLM App |
| 83 | Gas-Powered trimmers and blower | 15 - 20 feet away | NIOSH SLM App |
| 83 | Gas-Powered trimmers and blower | 15 - 20 feet away | NIOSH SLM App |
| 88 | Gas-powered generator for lights | 2 feet away – left side | LD831 |
| 91 | Gas-powered generator for lights | 2 feet away – front | LD831 |
| 89 | Gas-powered generator for lights | 2 feet away – right side | LD831 |
| 88 | Gas-powered generator for lights | 2 feet away – rear | LD831 |

## 4. CONCLUSIONS

### 4.1 Summary of Data

These data are preliminary field estimates of worker noise dose and equipment sound levels for two different hedge-trimming crews. They are not meant to define with statistical significance the noise dose or sound power levels. These data are, however, very useful in suggesting whether these battery-powered equipment are viable options in terms of lowering noise exposure and effectiveness in the task of hedge-trimming.

Overall, the measurements made on August 7, 2018 show a promising difference in noise experienced by the hedge-trimming crews using battery-powered vs. gasoline-powered equipment despite the challenges of collecting field data. For instance, the projected dose (Table 1), shows that when using the more protective NIOSH criteria, workers would have experienced about 103% projected dose (battery-powered trimmer) and 35% projected dose (battery-powered blower). On the other hand, by the same criteria the doses of the crew using gasoline-powered equipment would have been about 2,320% (gasoline-powered blower) and 518% (gasoline-powered trimmer). Instantaneous SLM measurements taken at various locations around the landscaping workers corroborate the dosimetry results. These SLM measurements were short-term average readings made over approximately 10 seconds each (Table 2.)

The ultimate utility of using gasoline-powered or battery-powered equipment for the task of hedge-trimming is based on several key evaluation factors that affect the work performed by hedge-trimming crews and the purchase of landscape maintenance equipment:

- Regarding *safety*, the battery-powered equipment is quite promising. Reducing noise levels to the point where workers don't have to rely on hearing protection as the primary control is greatly desired. Furthermore: 1) at least one worker stated that the battery-powered hedge-trimmer is much lighter (11.4 lbs. vs. 15.4 lbs + fuel according to manufacturer website) and greatly improves ergonomics over an entire shift; and 2) workers and supervisors noted that battery-powered equipment didn't produce exhaust vapor and fumes which made a big difference in their comfort, and potentially their health, throughout the workday.
- Regarding *quality of grounds and facilities*, landscaping management stated that the battery-powered blowers work at least as well as their gasoline-powered counterparts. Regarding hedge trimmers, management stated that gasoline-powered versions work as well, except when the hedges have thick-diameter foliage like old-growth or certain hedge varieties like viburnum. For these situations, gasoline-powered hedge-trimmers are still preferred.
- Regarding the e*conomic feasibility of using gasoline- or battery-powered equipment*, landscaping maintenance management stated that ideally, battery-powered equipment would last as long as gasoline-powered equipment– about 18 months. In addition, management stated that battery-powered equipment needs to last for an entire workshift. Lastly, the cost of maintenance is an issue and the battery-powered trimmers evaluated fail more frequently than the gasoline-powered versions according to landscape maintenance management.

Other conclusions suggested by the results include the following:

- Even though both battery-powered hedge trimmers were the same manufacturer and model number, one was louder than the other by about 3 dB (see Table 4). Just listening to the difference confirmed that battery-powered hedge trimmer B was quieter than hedge trimmer A. This sound level difference suggests that hedge trimmer A may need some maintenance and that the organization may wish to re-evaluate its preventive maintenance schedule for these trimmers.
- Other equipment in the area could be quite loud, for instance the gasoline-powered generator for lighting ranged from about 88-90 dBA and the dosimeter used for the riding lawn mower recorded readings of about 99 dBA.
- Workers in the hedge-trimming crew were potentially at or under the 85 dBA TWA recommended by NIOSH. Safety staff and management said that these workers should remain in the hearing conservation program since they routinely change to louder jobs on other workshifts and are frequently near other noisy equipment.

## 4.2 Recommendation 1: Continue evaluation of quieter hedge trimming equipment and other landscape maintenance equipment

The safety staff and management of this organization should be commended for their efforts to systematically evaluate and replace landscape maintenance equipment with improved versions that, among other advantages, may reduce workers' risk for noise-induced hearing loss. Decision makers may also wish to consider the following in their purchasing process:

- Looking at the systematic, factor-based procurement procedures outlined in SAE Standard AS6228 – "Safety Requirements for Procurement, Maintenance and Use of Hand-held Powered Tools" (SAE International, 2018). The approach outlined in this standard advocates for determining factors important in choosing power tools and using

a weighted grading system to guide purchasing. Best practices outlined in this standard would be worth noting.

- Simple, straightforward sound level measurements taken at set distances might help this organization standardize its evaluation of the possible effects of noise on guests. For instance, the standard ANSI/OPEI B175.2-2012 recommends sound level measurements at regular distances in at least 4 different directions for backpack blowers (ANSI, 2018). This basic approach would be a good basis for setting organizational testing standards for noise experienced by guests. Systematic measurements of this type could reduce or eliminate the influence of confounding factors like the generator background noise or differences in foliage cut in this field evaluation.

### 4.3 Recommendation 2: Consider evaluation of additional hazards related to hearing health

For the task of hedge trimming and others using gasoline-powered landscape maintenance equipment, safety staff should consider evaluating worker exposure to the hazards listed below if they aren't regularly doing so. Collecting this information would not only inform safety staff of potential hazards to workers but could also be used to inform and justify the purchase of less hazardous equipment. NIOSH is available to providing basic information about these hazards and to give feedback regarding methodology for assessing them:

- Research demonstrates exposure to certain chemicals, called ototoxicants, may cause hearing loss or balance problems, regardless of noise exposure and the risk of hearing loss is increased when workers are exposed to these chemicals while working around elevated noise levels (Department of Labor, 2018).
- Workers exposed to noise are at risk for other non-hearing loss related hazards. For instance, noise is associated with cognitive decline and cardiovascular outcomes such as hypertension and coronary heart disease. It is also strongly associated with depression. Tinnitus, which often co-occurs with hearing loss, can disrupt sleep and is associated with both depression and anxiety (American Heart Association, 2018).

### 4.4 Recommendation 3: Consider applying for the Safe-in-Sound Excellence in Hearing Loss Prevention Awards™

Considering that this organization's efforts to improve workers' hearing health go far beyond compliance with OSHA regulations, this organization might consider applying for the Safe-in-Sound Excellence in Hearing Loss Prevention Awards™. The Safe-in-Sound Excellence in Hearing Loss Prevention Awards™ (http://www.safeinsound.us/index.html#) honor excellent hearing loss prevention (HLP) practices in the work environment. Applicants are evaluated against key performance indicators in a review process designed to evaluate hearing loss prevention programs in the workplace (NIOSH/NHCA , 2018). Not only would this award bring recognition of the outstanding efforts of the landscape maintenance team but would also promote the implementation of practices leading to improved worker hearing health in the landscaping and grounds maintenance industry.

## 5. ACKNOWLEDGEMENTS

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