Noise Exposures During Potato Processing and Manufacture of Animal Feed

C. Achutan, R. L. Tubbs

ABSTRACT. *A noise exposure survey was conducted at an agricultural facility to evaluate noise exposures during potato processing and during the manufacture of alfalfa pellets. Of the 19 employees monitored, five reached or exceeded the National Institute for Occupational Safety and Health recommended exposure limit for occupational noise. Four of these employees were from the potato processing area, and one was from the alfalfa pellet-mill operation. Two of the five (bagger and pellet-mill operator) also exceeded the Occupational Safety and Health Administration action level. The facility has a well-managed hearing conservation program for employees in the potato processing area, but not in the alfalfa manufacturing area.*

Keywords*. Agriculture, Alfalfa, Dose, Dosimetry, Noise, Potato processing.*

Noise-induced hearing loss is one of the most prevalent occupational health hazards facing American workers today. According to the National Institute for Occupational Safety and Health (NIOSH), approximately 30 million people are exposed to hazardous levels of noise at their work sites (NIOSH, 1996). Studies have shown that agricultural workers experience one of the highest rates of hearing loss. Noise sources on the farm include heavy machinery used in crop cultivation and harvest (Depczynski et al., 2005; Holt et al., 1993; Solecki, 1998) and animal husbandry (Marvel et al., 1991; Kristensen and Gimsing, 1988; Humann et al., 2005).

Prolonged exposure to noise can result in irreversible hearing loss (McBride et al., 2003; Beckett et al., 2000; Firth et al., 2001; Solecki, 2002; Thelin et al., 1983). Noise-induced hearing loss is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss in addition to that which might occur as part of the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically (Ward et al., 2000). While noise-induced hearing loss is irreversible, it is preventable. The risk of developing noise-induced hearing loss can be reduced with the application of noise controls and occupational hearing loss prevention programs.

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The purpose of this study was to document noise sources and employee noise exposures at a medium-sized potato processing and alfalfa manufacturing operation. The observations and findings in this survey, as well as the recommendations, are relevant to farming operations in general.

Process

Potato Processing Operation

The potato processing plant is located in a rectangular area measuring approximately 60 m × 18 m. The major processes involved with potato processing and packaging are unloading of potatoes, sorting potatoes for quality and size, and packaging potatoes. Potatoes from the facility are used to make potato chips and other potato snacks.

Unloading

Potatoes are brought into the unloading area in trucks, rolled out of the trucks onto a conveyor, and transferred into a storage bin. Employees are positioned between the end of the truck and the beginning of the conveyor and along the conveyor to separate good potatoes from rotten potatoes, mud clods, and other debris. Unloading a truck takes approximately 30 min; four or five employees usually are involved with the process. During this survey, between four and eight truck loads of potatoes were unloaded each day. The potatoes are stored in a bin, from which they are sent to the washer. The washer is an automated process. When not unloading, employees assist with other tasks in the plant.

Sorting

Three sorting lines at this facility separate the potatoes by size and quality. The washed potatoes come off a conveyor to sorting line I. This sorting line is split into two lanes. Five metal bins are located between the lanes. Rotten potatoes are discarded in one of the bins, which are then transported outside the facility via a conveyor. In the remaining four bins, oversized or fused potatoes are placed for further processing. The rest of the potatoes are passed over a set of rollers that separates them by size. From there, the potatoes are sent to sorting line II, where potatoes are further sorted for size and quality, and sent for packaging. Potatoes discarded at sorting line II and the oversized and fused potatoes from sorting line I are further processed at sorting line III. At sorting line III, potatoes are discarded or sent for packaging. Two employees work in sorting line I, one on each lane. About four employees work in each of sorting lines II and III.

Packaging

The packaging operation includes one or two employees who assemble cardboard boxes, one who weighs boxes, two or three employees who feed boxes to the boxing line, three who stack the 23 kg (50 lb) filled boxes on pallets, four who fill and weigh 45 kg (100 lb) bags, two to three who stack the 45 kg bags on pallets, and a forklift driver who removes the stacked pallets for storage and shipment. There is also a semi-automatic line that sorts same-sized potatoes to their appropriate boxes.

Manufacture of Alfalfa Pellets

The manufacture of alfalfa pellets is done in a large room of approximately 225 m^2. The first step in the manufacture of alfalfa pellets used for animal feed is the grinding of raw alfalfa. The grinder is about 6 m high and 3 m wide. The grinder stands vertically; part of it is on the main floor, but most of it is in a basement. Raw alfalfa is loaded onto the grinder by a front-loader a little at a time, to prevent it from clogging. The alfalfa used to manufacture pellets is sometimes moldy and/or mixed with moldy hay. The alfalfa is

ground through the mechanical action of the grinder. The ground alfalfa is transported via a vacuum system to the pellet-mill, where under heat and pressure, it is compressed into pellets. The pellets have a 0.5 cm diameter and are cut into lengths of 15 to 20 cm. The pellets are cooled, sieved, and transferred to storage bins via a vacuum system. The pellet-mill operation is carried out by two employees: a front-loader driver who loads the alfalfa onto the grinder, and an operator who runs the pellet-mill machine.

Methods

Noise Sampling Strategy

Full-shift personal dosimetry was conducted on employees working in all parts of the potato processing area and on both employees working in the alfalfa pellet-mill operation. Employees were monitored during their work time and during their lunch break because they did not leave the facility. Seventeen employees were monitored in the potato processing area over a two-day period, including two unloaders, six sorters, and nine packagers. These employees were selected to represent noise exposures throughout the facility. The front-loader driver and pellet-mill operator from the alfalfa pellet-mill operation were each sampled for one day. These were the only workers in the alfalfa pellet-mill operation. In addition, spot-check, area noise measurements were obtained in various parts of the potato processing area and the alfalfa pellet-making operation to verify dosimeter data.

Noise Sampling Instrumentation

Quest Electronics model Q-300 noise dosimeters (Oconomowoc, Wisc.) were worn by the employees while they performed their daily activities. The noise dosimeters were attached to the wearer's belt, and a small remote microphone was fastened to the wearer's shirt at a point midway between the ear and the outside of the employee's shoulder. A windscreen provided by the manufacturer of the dosimeter was placed over the microphone during recordings. At the end of the day, the dosimeter was removed and paused to stop data collection. The information stored in the dosimeters was downloaded to a personal computer for interpretation with QuestSuite Professional computer software. The dosimeters were calibrated before and after the measurement periods according to the manufacturer's instructions.

Spot-checks of area noise were measured with a Quest Electronics model 2400 sound level meter (SLM). The instrument was set to measure noise levels between 70 and 140 dB on an A-weighted slow-response scale (dBA). The SLM was calibrated before and after the measurement periods according to the manufacturer's instructions.

Exposure Standards

The dosimeters collect data so that one can directly compare the information with the three different noise criteria used in this survey, the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and action level (AL), and the NIOSH recommended exposure limit (REL). The OSHA standard for occupational exposure to noise (OSHA, 1992) specifies a maximum limit of 90 dBA for a duration of 8 h per day, using a 5 dB time/intensity trading relationship. The NIOSH REL (NIOSH, 1998) uses an exposure criterion of 85 dBA for 8 h. The NIOSH criteria use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. The OSHA and NIOSH standards also provide a formula based on the above limits for calculating daily dose; during any 24 h period, a worker is allowed up to 100% of his daily noise dose. The OSHA standard includes an AL of 50% dose; an employer is required

Table 1. Dosimeter settings.

Parameters	OSHA Action Level	OSHA Permissible Exposure Limit	NIOSH Recommended Exposure Limit
Logging interval	1 min	1 min	1 min
Weighting	A	A	A
Threshold	80 dB	90 dB	0 dB
Exchange rate	5 dB	5 dB	3 dB
Criterion	85 dB	90 dB	85 dB
Time constant	Slow	Slow	Slow
Upper limit	115 dB	115 dB	115 dB

to administer a continuing, effective hearing conservation program when the AL is exceeded. The instrument parameters used to calculate noise levels by OSHA and NIOSH criteria are listed in table 1.

Results and Discussion

Nineteen full-shift dosimeter samples were collected during the evaluation. A summary of the personal dosimeter results is presented in table 2. Area measurements taken at various locations in the potato processing and pellet-mill areas are provided in table 3. The dosimeter also provides real-time exposure monitoring over the sampling period. Each data point represents the integrated average noise for a 1 min period, using the NIOSH 3 dB exchange rate. Typical graphs from the survey are shown in figures 1 through 3. The graphs have a lower limit of 70 dBA, which is the lowest noise value the dosimeters captured.

Potato Processing

In the potato processing facility, employees' noise exposures were below the OSHA PEL. The OSHA AL was exceeded once, and one reading (84 dBA) approached the OSHA AL of 85 dBA. In four instances, the noise exposures were at or exceeded the NIOSH REL. In two instances, the percentage of daily dose exceeded 100%, as computed by the NIOSH formula, and in two additional instances it exceeded 90%. The allowable dose was not exceeded by the OSHA computation based on the PEL criterion. Noise

Table 2. Personal noise dosimeter results.

		Percent Dose[a]		
Job Title	Number	OSHA Action Level	OSHA Permissible Exposure Limit	NIOSH Recommended Exposure Limit
Unloader[b]	2	16.8 - 18.5	0.5 - 0.7	36.6 - 40.1
Sorter[b]	6	29.8 - 43.3	0.1 - 0.6	60.4 - 94.6
Packager[b], [c]	9	25.1 - 76.5	0.2 - 43.2	55.0 - 358.9
Operator[d]	1	100.8	73.9	458.6
Front-loader[d]	1	20.4	2.3	47.2

[a] The dose percentages are the amounts of noise accumulated during a work day, with 100% representing the maximum allowable daily dose. If the OSHA action level exceeds 50%, the employer is required to administer a continuing, effective hearing conservation program.
[b] Employees working in the potato processing area and monitored for a full work shift (7 to 8 h).
[c] Includes box makers, baggers, pallet stackers, plastic bag and box packers, and box loaders.
[d] Employees working in the alfalfa manufacturing area and monitored for a full work shift (6 h).

Table 3. Area noise levels in potato processing and alfalfa pellet-making operation.

Department	Location	Noise Level (dBA)
Potato processing	Sorting line I	91
	Sorting line II	86
	Sorting line III	87
Alfalfa pellets	Edge of grinder turret opening	86
	Stairway to grinder	91
	Downstairs	105
	Output end	94
	Platform next to control booth	100
	Control booth door open	87
	Control booth door closed; electric cord blocking seal	80

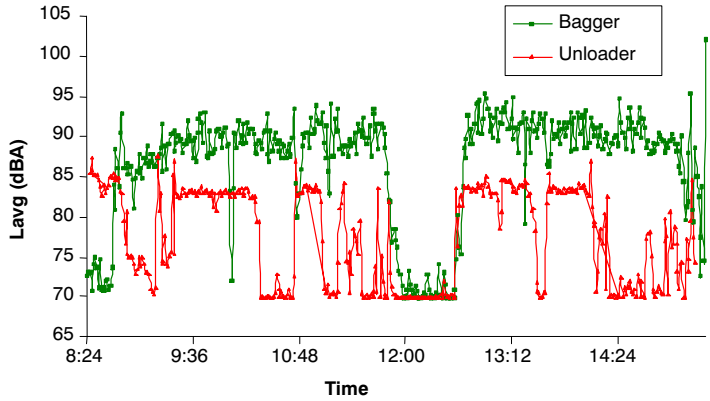

Figure 1. Typical noise exposures for unloaders and baggers in the potato processing area, showing higher noise levels for baggers.

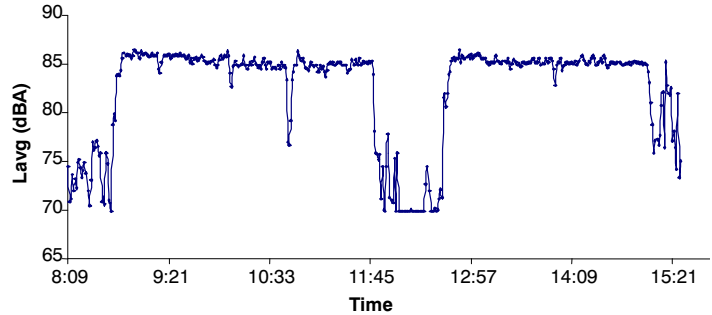

Figure 2. Typical noise exposures for sorters in the potato processing area; exposures remained fairly constant during sorting.

exposures in the packaging area were higher than those in the unloading and sorting areas. As shown in figure 1, exposures among the unloaders increased sharply, stayed constant during the unloading process, and then dropped sharply at the conclusion of the tasks. Smaller peaks with a rapid response time may be attributable to other tasks performed by the unloader, such as making boxes and feeding boxes to the line. Noise exposures to the sorters were uniform throughout the day. A typical noise profile is shown in figure 2.

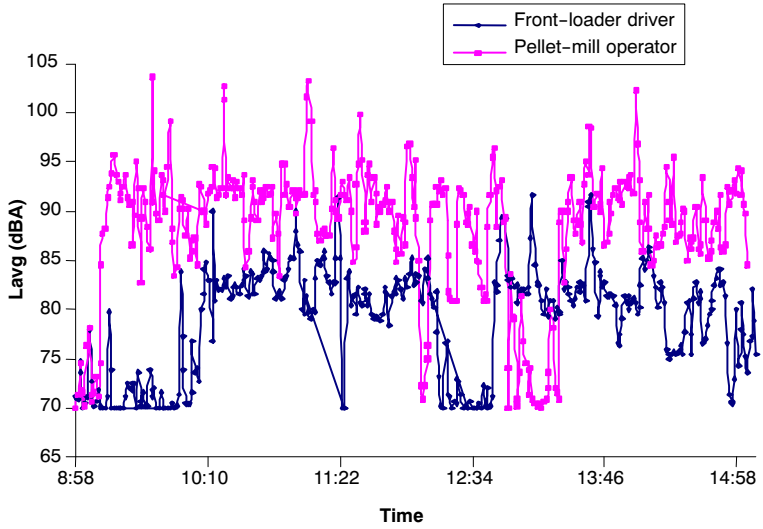

Figure 3. Profile of noise exposure to the front-loader driver and pellet-mill operator during the manufacture of alfalfa pellets. Noise exposure to the pellet-mill operator is higher than that of the front-loader driver.

The hearing protection devices (HPDs) provided for exposed workers (formable earplugs) was adequate to reduce exposures to below the NIOSH REL, provided that it is used properly and consistently. We observed good compliance with the wearing of the earplugs during the two-day survey.

Sound level measurements in various parts of the potato processing area showed that noise levels were between 85 and 93 dBA. The highest noise level was recorded next to a machine guard in the sorting area. The machine guard was worn out, thus exposing the belts that power the sorting machine.

This survey is comparable to a similar, smaller survey NIOSH conducted at this facility in August 1998 (McCammon, 1998). During the 1998 survey, production was not to capacity and there were many equipment failures, which led to a less-than-typical work environment. Nevertheless, personal dosimeter samples collected on four individuals during the 1998 survey exceeded the NIOSH REL and, in two instances, exceeded the OSHA AL. Sometime after the 1998 survey, the facility instituted engineering modifications to the equipment to further reduce noise exposure. These modifications included rollers with ball bearings and the incorporation of elastic materials between roll structure and metal braces. These changes have reduced the noise levels in the potato processing area, as evidenced by comparing empirical data collected by McCammon (1998) with this evaluation. Employees, too, have noticed a reduction in noise levels in the potato processing area.

Ewers and Tapp (2001), in reporting endotoxin exposures during potato processing, described a potato processing plant that operates 24 h a day, seven days a week, with approximately 850 employees. Furthermore, they mentioned that this company operates several potato processing plants in the U.S. The facility described in this study is probably smaller than the facility described by Ewers and Tapp, and smaller than most other potato processing facilities. It is likely that the noise exposures in this evaluation may not be generalizable to larger facilities. More research is needed to assess employee noise exposures in larger facilities. The work activities in the facility described by Ewers and Tapp are similar to the work activities observed in our study.

Manufacture of Alfalfa Pellets

During the manufacture of alfalfa pellets, the noise exposure to the pellet-mill operator exceeded the OSHA AL and the NIOSH REL, but was below the OSHA PEL of 90 dBA. The front-loader operator's exposure was below all exposure criteria, probably because he was up high in the vehicle and spent a good portion of the day away from the grinder. The front-loader had a cab, but it was open at least part of the day. Figure 3 compares the noise exposures to the pellet-mill operator and the front-loader driver. The pellet-mill operator's exposure was higher than that of the front-loader driver, probably because the operator was right next to the mill most of the day. The noise levels generated by the grinder ranged from 86 to 105 dBA, as shown in table 2.

Of the two employees sampled during the manufacture of alfalfa pellets, the noise exposure to the front-loader driver was below all exposure criteria. Thus, this employee is not required to be part of a hearing conservation program. The noise exposure to the pellet-mill operator exceeded the OSHA AL and the NIOSH REL, and was close (88 dBA) to the OSHA PEL. Any employee who runs the pellet-mill should be included in a hearing conservation program. The operator controls the machine operation from a control booth, which can afford adequate noise protection. The noise level on a platform outside the booth was 100 dBA, but it dropped to 80 dBA with the door partially closed. The door could not be completely closed because an electric cord was blocking the opening. It would be prudent to run the wire through the wall, via a conduit, thus allowing the door to be shut completely. We also observed that the pellet-mill operator spends a great deal of time outside the control booth; his use of HPDs was intermittent while out of the booth.

A limitation of this evaluation was that, for logistical reasons, we were only able to monitor the two employees for one day. However, we were told that the work activities observed were representative of a normal work day. We were not able to find other studies in the scientific literature describing employee noise exposures in the manufacture of alfalfa pellets; therefore, we are not able to comment on how the results from this study may be representative of the industry as a whole.

Conclusions and Recommendations

The noise exposure assessment revealed that of the 19 employees who were monitored, five attained or exceeded the NIOSH REL. Four of these employees were from the potato processing area, and one was from the alfalfa pellet-mill operation. Two of the five (bagger and pellet-mill operator) exceeded the OSHA AL. None of the employees exceeded the OSHA PEL.

Overall, the noise exposures at this facility are well managed. Employees who work in areas with exposure to loud noise are provided foam earplugs that are capable of reducing their noise exposure to an acceptable level. Employees were observed wearing their earplugs properly. The facility has a hearing conservation program for employees in the potato processing area; employees are sent to occupational medicine physicians for annual hearing examinations. In addition, the company has reduced noise levels by instituting engineering changes in the potato processing equipment.

Human speech and machine sounds both contain high and low frequencies that can be distorted by conventional HPDs. To minimize this distortion, and to improve communication, we recommend the use of HPDs that are flat (hearing protectors that reduce frequencies from 125 to 8000 Hz by about the same amount) and more moderate in attenuation. Additionally, a maintenance program for noise controls needs to be implemented to ensure that the controls continue to function as designed.

The pellet-mill operator should be enrolled in a hearing conservation program. The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping. The operator should also limit the amount of time spent outside the control booth and continue to wear ear protection when outside the booth. The door on the control booth should be closed tightly when the operator is inside.

References

Beckett, W. S., D. Chamberlain, E. Hallman, J. May, S. A. Hwang, M. Gomez, S. Eberly, C. Cox, and A. Stark. 2000. Hearing conservation for farmers: Source apportionment of occupational and environmental factors contributing to hearing loss. *J. Occup Environ. Med.* 42(8): 806-813.

Depczynski, J, R. C. Franklin, K. Challinor, W. Williams, and L. J. Fragar. 2005. Farm noise emissions during common agricultural activities. *J. Agric. Safety Health* 11(3): 325-334.

Ewers, L. M., and L. C. Tapp. 2001. Endotoxin exposures during potato processing. *Applied Occup. Environ. Hyg.* 16(12): 1079-1087.

Firth, H., P. Herbison, D. McBride, and A. M. Feyer. 2001. Health of farmers in southland: An overview. *New Zealand Med. J.* 114(1140): 426-428.

Holt, J. J., S. K. Broste, and D. A. Hansen. 1993. Noise exposure in the rural setting. *Laryngoscope* 103(3): 258-262.

Humann, M. J., K. J. Donham, M. L. Jones, C. Achutan, and B. J. Smith. 2005. Occupational noise exposure assessment in intensive swine farrowing systems: Dosimetry, octave band, and specific task analysis. *J. Agromed.* 10(1): 23-37.

Kristensen, S., and S. Gimsing. 1988. Occupational hearing impairment in pig breeders. *Scandinavian Audiol.* 17(3): 191-192.

Marvel, M, D. Pratt, L. Marvel, M. Regan, and J. May. 1991. Occupational hearing loss in New York dairy farmers. *American J. Ind. Med.* 20(4): 517-531.

McBride, D. I., H. M. Firth, and G. P. Herbison. 2003. Noise exposure and hearing loss in agriculture: A survey of farmers and farm workers in the Southland region of New Zealand. *J. Occup. Environ. Med.* 45(12): 1281-1288.

McCammon, J. 1998. Health hazard evaluation report: Navajo agricultural products industry, Farmington, N.M. HETA 98-0315. Denver, Colo.: National Institute for Occupational Safety and Health.

NIOSH. 1996. Preventing occupational hearing loss: A practical guide. DHHS (NIOSH) Pub. No. 96-110. Cincinnati, Ohio: National Institute for Occupational Safety and Health.

NIOSH. 1998. Criteria for a recommended standard: Occupational noise exposure (revised criteria 1998). DHHS (NIOSH) Pub. No. 98-126. Cincinnati, Ohio: National Institute for Occupational Safety and Health.

OSHA. 1992. 29 CFR 1910.95. Washington, D.C.: U.S. Government Printing Office, Office of the Federal Register.

Solecki, L. 1998. Occupational hearing loss among selected farm tractor operators employed on large multiproduction farms in Poland. *Intl. J. Occup. Med. Environ. Health* 11(1): 69-80.

Solecki, L. 2002. Hearing loss among private farmers in the light of current criteria for diminished sense of hearing. *Annals Agric. Environ. Med.* 9(2): 157-162.

Thelin, J. W., D. J. Joseph, W. E. Davis, D. E. Baker, and M. C. Hosokawa. 1983. High-frequency hearing loss in male farmers of Missouri. *Public Health Rep.* 98(3): 268-273.

Ward, W. D., L. H. Royster, and J. D. Royster. 2000. Chapter 4: Anatomy and physiology of the ear: Normal and damaged hearing. In *The Noise Manual*, 101-122. 5th ed. E. H. Berger, L. H. Royster, J. D. Royster, D. P. Driscoll, and M. Layne, eds. Fairfax, Va.: American Industrial Hygiene Association.