National Farm Injury Data Centre

Farm Noise Hazards: Noise Emissions during Common Agricultural Activities

shaping the future

Farm Health & Safety Joint Research Venture
Rural Industries R&D Corporation
Grains R&D Corporation
Cotton R&D Corporation
Sugar R&D Corporation
Meat & Livestock Australia
Dairy R&D Corporation
Horticulture Australia Ltd

RIRDC
RURAL INDUSTRIES RESEARCH & DEVELOPMENT CORPORATION

AUSTRALIAN CENTRE FOR AGRICULTURAL HEALTH AND SAFETY

Australian Centre for Agricultural Health and Safety

Farm noise hazards: noise emissions during common agricultural activities

Julie Depczynski
Richard C Franklin
Kathy Challinor
Warwick Williams
Lyn J Fragar

November 2002

Funded by the Farm Health and Safety Joint Venture and New South Wales Health

ISBN: 0642 5853 85

Publication No.:R02-139
Project Number: US-111A

Researcher contact details:
R Franklin
Australian Centre for Agricultural Health and Safety
School of Rural Health
University of Sydney
PO Box 256
Moree NSW 2400
Ph: 02 6752 8215 Fax: 02 6752 6639
Website: http://www.acahs.med.usyd.edu.au/nfidc
E-mail: rfranklin@health.usyd.edu.au

RIRDC contact details:
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquaries Street
Barton ACT 2600
PO Box 4776
Kingston ACT 2604
Phone: 02 6272 4539 Fax: 02 6272 5877
Website: http://www.rirdc.gov.au
E-mail: rirdc@rirdc.gov.au

Published in November 2002

Suggested citation:
Depczynski J, Franklin RC, Challinor K, Williams W , Fragar LJ (2002). *Farm Noise Hazards: noise emissions during common agricultural activities.* ACAHS & RIRDC: Moree

FOREWORD

This report provides a collection and analysis of data pertaining to noise emission from farm machinery. Examination of different activities, from a range of industries was undertaken to allow preparation of guidance material for farmers to help reduce their exposure to harmful noise.

Farmsafe Australia has an active program aimed at reducing the number of farmers (in particular young adults – 15-24 years) with noise injury. This document is intended to inform the work of Industry and Farmsafe Australia in particular who are in the process of developing a strategy for noise injury on farms.

The Rural Industries Research and Development Corporation and the Australian Centre for Agricultural Health and Safety are both proud members of Farmsafe Australia, and have taken responsibility for improving the data and evidence base that the industry is using to guide its injury prevention programs.

The project was funded by the research and development corporations contributing to the Farm Health and Safety Joint Venture - Rural Industries Research and Development Corporation, Grains Research and Development Corporation, Australian Wool Innovation Limited, Cotton Research and Development Corporation, Sugar Research and Development Corporation and Meat and Livestock Australia. The Joint Venture is committed to improving well-being and productivity of the agricultural industries through careful investment in research and development programs that assist industry to manage OHS risk in a cost effective way.

This report, a new addition to RIRDC's diverse range of over 700 research publications, forms part of our human capital, communications and information systems R&D program, which aims to enhance human capital and facilitate innovation in rural industries and communities.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- Downloads at http://www.rirdc.gov.au/reports/index.htm
- Purchases at http://www.rirdc.gov.au/eshop

Dr Simon Hearn
Managing Director
Rural Industries Research and Development Corporation

ACKNOWLEDGEMENTS

The authors would like to thank all of the farmers, farm managers and farm workers who allowed us onto their properties, gave their time to answer questions, and started and stopped equipment without complaint.

ABBREVIATIONS

ACAHS	Australian Centre for Agricultural Health and Safety
dB	Decibels
FSA	Farmsafe Australia
Hrs	Hours
L_{Aeq}	Average noise level (A-weighted)
L_{Peak}	Peak noise level (Unweighted)
NEC	Not Elsewhere Classified
NSW	New South Wales
PTO	Power Take Off
Qld	Queensland
RIRDC	Rural Industries Research and Development Corporation

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

Title: Farm noise hazards: noise emissions during common agricultural activities
Authors: Depczynski J, Franklin RC, Challinor K, Williams W, Fragar LJ
ISBN: 0642 5853 85
Publication Date: November 2002

The aim of this project was to gather up-to-date information on farm noise levels across a range of agricultural industries, to reflect the current noise exposure risks of farmers and others within the farming context. This information is to be used to inform and update current resources used to assist farmers to better manage farm noise for their own, their worker's and their families hearing health.

Farm visits were conducted on 48 farms across a range of producer groups, with noise levels recorded at the ear of the operators and any others in close proximity to noisy activities on farm. The average and peak noise levels were recorded for 56 types of machinery / activity sites on farm, totalling 298 separate items/activities.

Common noise hazards identified through this study which produce excessive noise include:

- Firearms
- Uncabined tractors
- Workshop tools
- Small motors (eg. chainsaws, augers, pumps)
- Manual – fed piggeries
- Shearing sheds
- Heavy machinery – particularly older field machinery used for long hours such as cabined tractors, harvesters (grain, cotton, and sugar cane), bulldozers and cotton module presses.

It was considered that the most extreme noise hazards on the farm (if unprotected) were firearms and uncabined tractors. These represent the two main difficulties in the relationship between noise level and exposure time. That is, high intensity/short exposure time vs. lower intensity/longer periods of exposure. Frequently a noise at a much lower level is not seen as a potential hazard; hence precautions are not taken, for example when using a tractor for long periods. Alternatively, the short duration of noise from a firearm discharging does not indicate the extreme sound energy produced which can cause instant damage to hearing. Other farm noise hazards may be more easily recognised (eg. workshop tools) perhaps with precautions more readily taken. These highlight the importance of considering both noise level and exposure time when assessing the risk of noise injury by a particular hazard.

A number of factors were examined for their effects upon the noise level at the ear of operators and others. These included age of machinery, radios, cabins and long operating hours. This would have implications for the choice of strategies to reduce noise and limit noise exposure and in the appropriate use of hearing protection. It is hoped that a greater awareness of these factors through dissemination of this information, will contribute to the quality of programs aimed at preventing noise injury amongst farmers, farm workers and farm families.

INTRODUCTION

The aim of this project was to gather up-to-date information on farm noise levels across a range of producer groups, reflecting the current noise exposure risks of farmers within the farming context. Noise injury is a significant problem in the Australian farming community. Two-thirds of over 6,000 farmers screened at field days through the NSW Rural Noise Injury Prevention Program, show signs of noise injury on audiogram (Franklin et al In Press). Evidence from this program and others has indicated this is due to the prolonged exposure to on-farm noise hazards such as tractors, chainsaws and firearms (Challinor, Franklin & Fragar.1999.2). In a South Australian farm noise study, it was demonstrated that average hearing levels expected for the farming community were 10 to 15 years worse than the rest of the population. (Williams, Forby-Atkinson, Purdy and Gartshore.2002).

Damage to hearing can be caused by prolonged and cumulative effects of noise over many years which results in metabolic damage to the cochlear; or by acoustic trauma associated with peak noise levels over 140dB, which cause instant damage to hearing structures (Clark and Bohne. 1999). If a group of individual workers are exposed to an average A-weighted, continuous noise level of 85dB for eight hours a day { L_{Aeq8h} 85dB(A)}, it has been estimated that at the end of a ten year working period 6% of those individuals can expect to have a hearing loss that influences their everyday living (ISO. 1999). This means for example, that they need to turn up the volume on the television; don't hear the telephone, frequently ask for words or phrases to be repeated; don't reply when called from a distance; or have difficulty hearing conversation in large groups or in social settings such as at a club. As the time of exposure increases so too does the risk of hearing loss, to 22% at 20 years and 48% after 30 years. The risk of hearing loss increases more dramatically as the noise level increases. At an L_{Aeq8h} of 90dB(A), after 10 years the risk is 21% and at 95dB(A) the risk has risen to 28% (ISO 1999).

The various national and state regulatory standards and codes of practice take account of such evidence. The national standard (limit) for occupational noise exposure over an 8 hour working day is an A – weighted average noise level of 85dB(A) {L_{Aeq8h} = 85dB(A)}, with the peak C-weighted noise level limit at 140dB(C) {L_{Cpk} = 140dB(C)} (NOHSC, 1007(2000)). Weightings refer to the measurement instrumentation and are described in relevant Australian Standards (AS 2659.1 -1988). Each state has regulations and codes of practice which provide detail about meeting these OHS standards. Currently in some states, the L_{peak} is measured unweighted, however this is gradually being replaced by the C-weighted equivalent in line with the national standard.

The provision of hearing screening to farmers participating in the NSW Rural Noise Injury Prevention Program involves discussion with the participant on the effects of noise and advice on noise management, including the use of hearing protectors. A package of "take-home" material includes information on some typical farm noise emissions and exposure limits, originating from Victorian Department of Agriculture data of the 1980's. This has been extracted from guidance material on farm noise produced by the Australian Centre for Agricultural Health & Safety (1997).

Information from this study regarding on-farm noise risks will be incorporated into the advice provided to farmers at field days that attend hearing screening programs and included in their "take-home" material. This will help to maintain the relevance and quality of information received at hearing screening sessions. The study results will also contribute to understanding farm noise injury risks as part of a national strategy on noise injury prevention currently in development. As part of this wider program of action, it is envisaged that information from this study will better enable farmers to manage farm noise for their own hearing health; as well as assist them in meeting their requirements under the various state Occupational Health and Safety Acts.

METHODOLOGY

The farms visited in this study were to represent a variety of production systems, including grains, cotton, mixed farming, sheep, cattle, poultry, pigs, horticulture, dairy and sugar industries. To obtain on-farm noise levels, the plan was to measure noise levels at the ear of the operator and any others close by, on a range of noisy machinery or farm activities, for as many farms across these producer groups as possible in the time available.

Training

An initial period was required to obtain resources and to educate/train the field researcher. A consultant in acoustical engineering / noise assessment from the National Acoustic Laboratories, was recruited to assist with this part of the project. Training included competency in field noise assessment and the appropriate use of the integrating sound level meter according to Australian Standards AS/NZ 1269.1:1998 and AS 2659.1:1988. A pilot set of measurements on seven machinery types at a nearby farm was performed to refine measurement techniques and field procedures.

Equipment

A CEL 440 integrating sound level meter was used for the project, fitted with a QE4146 microphone and 1/1 Octave filter. This is a Type 1 precision instrument, accurate to within +/-0.7dB(NOHSC:2009(2000)). Appropriate calibration testing was performed and calibration certificate issued on 23/1/02, prior to commencing the project's field measurements. General field noise assessments require a Type 2 instrument (+/-1.0dB) or better (NOHSC:2009(2000)). Therefore, the sound meter used was above the minimum standard required for the project.

Technique

A calibration check of the integrating sound level meter was performed with an acoustic calibrator before each set of measurements (on - farm visit). This was to ensure accuracy of the instrument within +/- 1.0dB, consistent with Type 2 precision instruments and general field purposes (AS 1259.2–1990; NOHSC:2009, 2000). Noise level measurements were taken orienting the microphone toward the noise source and within 10cm of the ear of the operator; (AS/NZS 1269.1) and at the equivalent positions of others who may be around when the machinery is being used or the activity being performed.

Measurements consisted of the average noise level (L_{Aeq}) and peak noise level (L_{Peak}) in decibels (dB) received at the ear over the measurement period. The former uses an A-weighted logarithmic scale which approximates the frequency - dependent response characteristic of the human ear at lower frequencies (AS 2659.1-1988). That is, the readings take into account the sensitivity of the ear toward certain frequencies and approximate the level of sound actually being heard. Peak sound levels are recorded using an unweighted linear logarithmic scale. This approximates the level of sound being emitted regardless of the frequency-dependent biases of the human ear (AS 2659.1-1988). The upper sound level limit of the instrument used was 140dB, with levels of 144dB indicated when the sound level was beyond the instrument's range.

The period of measurement was determined by ascertaining a length of time where average noise levels were stable on the sound meter display. Typical periods of measurement were 20 – 30 seconds, or several minutes for less constant noise (eg pig squealing, cotton module press). In the case of firearms, only the peak measurement (L_{Peak}) was obtained, as the split second nature of the noise event rendered the average level irrelevant.

Sampling

A snowball sampling method was used to make contact with individual farmers. This is an acceptable sampling method when there are limitations which make it impossible to achieve a probability sample, or when there is difficulty approaching respondents in any other way (Sarantakos 1998). These conditions applied to this project, due to the limited timeframe for the research. Farmers were invited from across northern NSW and southern QLD to participate in the Project, chiefly through existing networks (eg Farmsafe Action groups, producer representatives), as well as by other farmers "word-of-mouth". For this reason, some time passed before the project "gained momentum." Farmers were contacted by phone to obtain permission to conduct the noise measurements, with a supporting written outline of the aims and requirements of the project sent by mail or facsimile.

On farm procedures

The farm visit comprised of:

- Identification of the major noise risks on that particular farm.
- Where possible, the recording of noise levels at the ear of operators (and others) of these key noise hazards, using a calibrated integrating sound level meter complying with AS 1259.2 - 1990.
- An on-site interpretation given to the farmer regarding the noise level and approximate exposure times before risk of hearing damage.
- Any other recommendations as appropriate in discussion with farmers regarding farm noise, noise reduction strategies and hearing protection.

The field researcher conducted noise measurements at the ear of the participating farmer (and where others might be located), for different farm activities/machinery. These included tractors, harvesters, augers, workshop tools, chainsaws, firearms, shearing sheds, dairies, packing sheds, and all terrain vehicles.

The variable operating conditions under which measurements were taken were also recorded. These included weather conditions, idle vs. working revolutions; empty vs. full machinery; and the presence of secondary implements. With the exception of measurements taken of horticultural field workers using harvest-aids and lettuce transplanters, measurements were conducted under mild / dry conditions with light to very light wind conditions during a particularly stable weather period.

Where possible, farmers were asked to set their machines at both idling and working phases. It was indicated if the activity / machine was in a shed or in the open, with machinery / activities recorded in their normal operating location. That is, field machinery in the field – workshop tools in workshops with their local reverberatory effects, and shed workers such as packers and shearers, in sheds. Whilst most augers were used and measured in the open, two were also used and recorded in sheds.

The noise was described as either steady state or impulsive state. Examples of the latter include 'firearms', 'post-driver' and 'metal on metal'. Steady state noise was recorded using the A-weighted scale for the average noise level (L_{Aeq}). For the equipment producing impulsive noise, the peak noise level was the most appropriate measure, which for this sound meter could only be expressed in the linear unweighted scale (L_{Peak}.).

It was noted if the machinery was operating under simulated or actual operating conditions. Where possible machinery was measured during a typical activity (eg. tractor pulling a plough), though this was not always achievable. Where it was possible, comparative noise levels were taken for both 'working revs' as defined by the farmer and those when 'using a secondary implement' for the same machine. This helped to assess the appropriateness of noise measurements for those machines where pulling a secondary implement was not carried out.

Farmers were asked to turn on the radio if one was present (eg. within cabined machinery), measurements being taken with radio on and off for comparison. They were also asked to approximate their typical exposure times at any one time/or in a day/season/year. This assisted in discussions with the farmer as to the particular risk to hearing posed by the machinery/activity – risk of noise injury being a factor of both the noise level and the length of time exposed to it (Australian Agricultural Health Unit. N/96/1).

Analytical methods

Noise level data was entered into *Microsoft Access*™, with analysis undertaken using *SPSS*™. The identity of individual farmers was not linked to the pooled data. Descriptive statistics on range and central tendencies were obtained for average and peak noise emissions, for each machinery /activity. Where displayed in tables, the results have been rounded to the nearest whole number, as appropriate for the logarithmic decibel scale. Basic tests of association between variables and differences between means (correlation, chi-squared, t-tests of significance) were performed for the larger machinery samples such as tractors with and without cabins. Some machinery types were also grouped into aggregated categories for graphical comparison.

FINDINGS

A total of 48 farms were visited over a 3 - 4 month period from late February to mid May 2002. These produced a range of agricultural commodities and were spread across northern NSW and southern Qld (Table 1).

Dairies were of herringbone layout (up to 24 bays), milking between 80-260 cows twice daily. The poultry farm was an independent egg producing operation of 5,000 “Isabrown” hens. Of the piggeries, one was a feedlot with 2,000 pigs in 10 sheds, pigs ranging in age from 4 - 12months. These were fed using a continuous automatic feeding system, with minimal handling required. The other piggery included sows and suckers of various ages which were manually fed, with suckers requiring handling for detusking and immunisation. This piggery until recently consisted of 2,000 pigs, but on the day measurements were taken had only 250 pigs in 3 sheds.

Horticultural production at the farms visited included specialised operations for onion, lettuce, broccoli, corn, oranges and nuts, ranging from family only farms to enterprises employing over 100 workers. Sugarcane farms were considered by their owners to be small to medium size operations for the area, but shared the sugar-cane harvester through a co-operative of 10 farms in the valley. There was considerable mix in the proportions of sheep and cattle on grazing properties, so that these have been grouped. Such was also the case for mixed grains and livestock, with considerable diversity in production noted on the farms visited. Cotton farms were also set up to produce grains in various proportions according to season, water availability and commodity prices.

Table 1. Classification of farms by commodity group and geographical region

Commodity Groups	No. of farms	Geographical regions	No. of farms
Dairy	5	North Coast	5
Grains only	3	Northern Tablelands	7
Horticulture	8	Northwest Plains	19
Mixed grains / cotton	8	**NSW**	
Mixed grains / livestock	11	Northwest Slopes	10
Piggeries	2	**QLD**	
Poultry - eggs	1	Darling Downs	3
Sheep &/or cattle	8	Lockyer Valley	4
Sugar	2		
Total	**48**	**Total**	**48**

An average of six items of machinery or activity sites were measured per farm, totalling 298 items of machinery / activity sites (eg: shearing shed = one site with several worker measurements). Fifty-six different types of machinery / activity were identified in the survey. The timing of the project meant that some machinery in common use at other times of the year, were not available for noise measurement, as these were “shut-down” until the next season (eg. harvesters).

Average noise levels for major machinery / activity types

Average noise levels with 95% confidence intervals for operators and others during working conditions are represented in Table 2 for some of the more frequent machinery/activity types. This includes an average and confidence interval for age for each machinery sub-sample, and the recommended exposure limits for this machinery/activity without the use of hearing protection. The range and central tendencies for the average and peak noise levels received at the operator's ear (and some others), are presented for each of the 56 machinery/activity sites in Appendix 1. These occur at their 'typical' locations, in mild weather conditions, without radio and under 'engine-working' as opposed to idling conditions.

Operators

Figure 1a provides a box plot summary of the average and range in noise levels (L_{Aeq}) for 19 major machinery/activity types. For the impulsive noise event of a firearm discharging, the unmeasurable 'average' noise (L_{Aeq}) becomes the measurable peak (L_{Peak}) for the duration of the event. Therefore, it was considered valid to display 'firearm' for comparison as L_{Peak}. However, as firearms are so much higher than the next item, (chainsaws), Figure 1 also displays the same items excluding firearms, for closer comparison of other items.

The relatively small *n* for some pieces of equipment has resulted in a wide dispersion around the mean. This is particularly problematic for pig sheds where manual feeding occurred. There was high variability with regard to whether pigs were being handled. The upper range may be more significant in this case. The piggery with automatic feeders and minimal handling (ie feedlot piggeries with no breeding), was relatively quiet with noise levels averaging 72dB (Table 42). Variability within piggeries and other groups such as harvesters and air compressors was also apparent, due to outliers. This effect could be minimised in future studies, given more time to obtain larger sample sizes.

Table 2. Average noise levels and recommended exposure times for major machinery / activity types

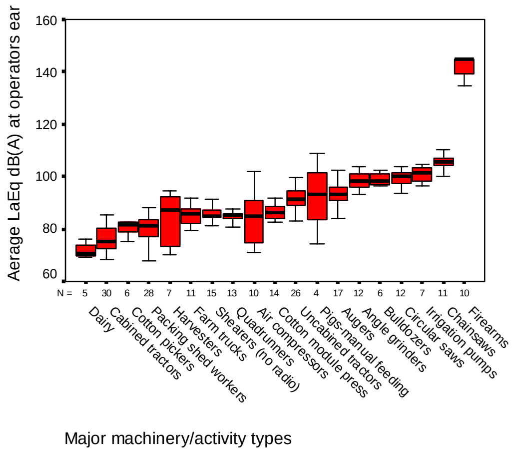
Machinery or Worker Position **[n = no. of items measured]**	**Age of machinery (yrs)** *Average & Range (95% CI)*	**Noise level at ear of operator/ normal working conditions** *Average & Range (95% CI)* L_{Aeq} dB(A)	**Recommended exposure limits. without hearing protection** ***NB: Noise exposure risk for each activity in the day is <u>cumulative</u> toward overall noise exposure risk.*****
Air compressors [n=10]	15 (10 - 19)	86 (77- 95)	7 hrs (15 mins - 8 hrs+)
All terrain vehicles [n=13]	7 (4 - 9)	86 (84 - 87)	7 hrs (4 - 8 hrs)
Angle grinders [n=12]	9 (4 - 14)	98 (96 - 100)	20 mins (15 - 30 mins)
Others in workshop [n=6 at 6 grinders]		90 (87 - 93)	2 hrs (1 - 5 hrs)
Augers	13 (6 – 20)	93 (89-96)	1 hr (30 mins – 3 hrs)
Bench grinders [n=6]	13 (1 - 24)	99 (94 - 104)	18 mins (5 mins - 1 hr)
Others in workshop [n=5 at 5 grinders]		89 (82 -96)	3 hrs (40 mins - 8 hrs)
Bulldozers [n=6]	27 (13 - 42)	99 (97 - 100)	18 mins (15 - 30 mins)
Chainsaws [n=11]	11 (6 - 15)	106 (104 - 107)	3 mins (2 - 5 mins)
Others stacking wood [n=6 at 6 chainsaws]		96 (93 - 99)	40 mins (15 - 50 mins)
Circular saws [n=12]	12 (7 - 15)	99 (98 - 101)	18 mins (10 - 20 mins)
Others in workshop [n=11 at 11 saws]		89 (84 - 94)	3 hrs (1- 8 hrs)
Cotton module presses [n=14]	12 (6 - 17)	86 (85 - 88)	6 hrs (4 - 8 hrs)
Others in field (rakers) [n=23 at 14 presses]		84 (82 - 86)	8 hrs (6 - 8 hrs)
Cotton pickers [n=6 of 8 pickers]	5 (2 - 5)	81 (78 - 85)	8 hrs (8 - 8 hrs+)
Av. <u>increase</u> with radio on [n=4 for 4 pickers]*		1 - 3 dB	4 hrs - 8 hrs+
Others in field (machines idle) [n=4 at 2 pickers]*		83 (77 - 89)	8 hrs (4 - 8 hrs+)
Others in field (machines turning) [n=2 at 2 pickers]*		94	1hr
Dairies - herringbone (16-24) bay, in pit [n=10 at 5 dairies]		73 (71 - 75)	no limit
Farm trucks [n=11]	24 (16 - 32)	85 (83 - 88)	8 hrs (4 - 8 hrs)
Firearms [n=10]	17 (9 - 24)	Lpk 140+ dB	no exposure
Forklifts [n=4]*	16 (10 - 21)	84 (81-88)	8 hrs (4 - 8 hrs)
Harvesters [n=7]	20 (6 - 34)	83 (75 - 91)	8 hrs (2 - 8 hrs +)
Av. <u>increase</u> with radio on [n=2 for 2 harvesters]*		2 - 5 dB	40mins - 8 hrs+
Others in field [n=2 for 1 harvester]*		90	2 hrs
Irrigation pumps [n=7]	17 (5 - 29)	100 (96 - 104)	15 mins (5 -30 mins)
Motorbikes - 2 wheel [n=2]*	4 (0-6)	81 (70 - 92)	8 hrs (1.5 - 8 hrs+)
Packing shed workers [n=28 in 6 packing sheds]		80 (78 - 82)	8 hrs+ (8 - 8 hrs+)
Pig handling - suckers [n=1shed in 1 piggery]*		109	1 - 2 mins
Pig sheds - manual feeding [n=3 sheds in 1piggery]*		87 (74 - 99)	5 hrs (15 mins - 8 hrs+)
Shearers [n=15 in 6 shearing sheds]		86 (84 - 87)	7 hrs (4 - 8 hrs)
Others in shed [n=11 in 7 sheds]		80 (77 - 83)	8 hrs+ (8 - 8 hrs+)
Sugarcane harvester [n=1]*	4	86	7 hrs
<u>Increase</u> with radio on		2	4 hrs
Tractors with cabins [n=30]	7 (4 - 10)	76 (75 - 78)	no limit
Av. <u>increase</u> with radio on [n=22]		3 - 5 dB	8 hrs - 8 hrs+
Others in field [n=9 at 6 tractors]		85 (80 - 90)	8 hrs (2 - 8 hrs+)
Tractors without cabins [n=26]	20 (15 - 24)	92 (90 - 93)	1.5 (1 - 2) hrs
Others in field [n=13 at 10 tractors]		82 (78 - 86)	8 hrs (6 - 8 hrs+)

* Sample sizes less than 5

** For example: If exposed to a noisy activity for half the recommended daily limit {eg. Angle grinder for 10 min of a 20 min daily limit), any remaining noise exposure in the day should not exceed half the recommended daily limit for another activity {Eg. A limit of 4 hrs instead of 8hr on a tractor with a radio).

Figure 1. Mean and dispersion of L_{Aeq} dB(A) at operator's ear for main machinery / activity types

A. Including firearms



B. Excluding firearms

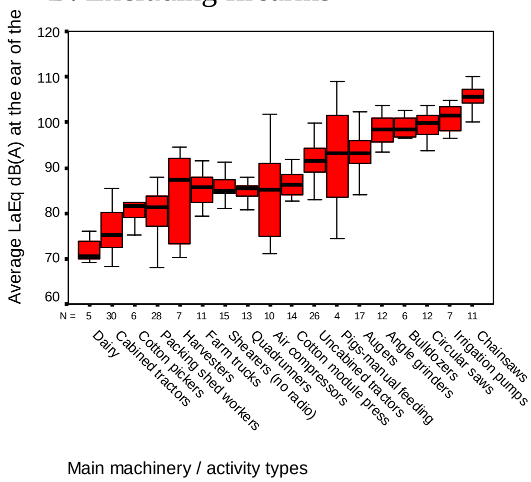
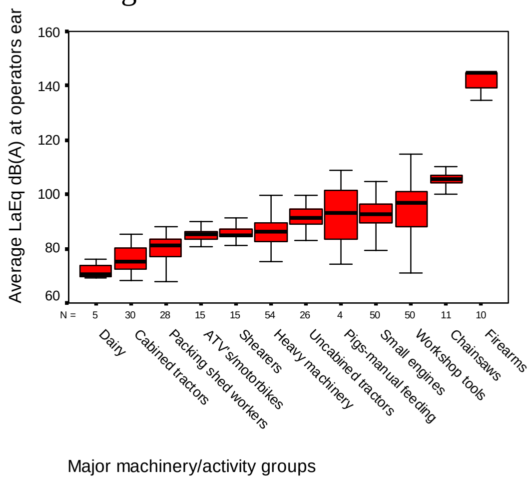
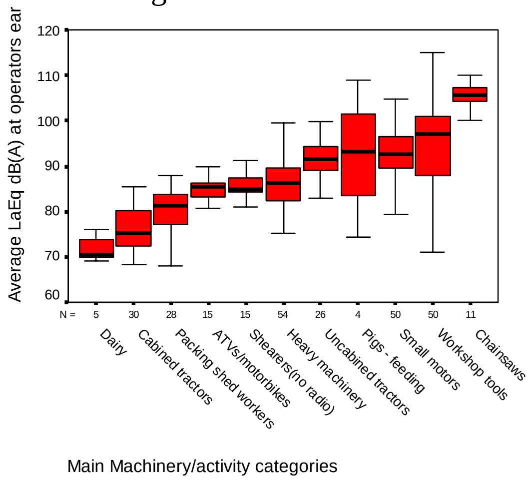


Figure 2. Mean and dispersion of aggregated machinery groups/activity

A. Including firearms



B. Excluding firearms



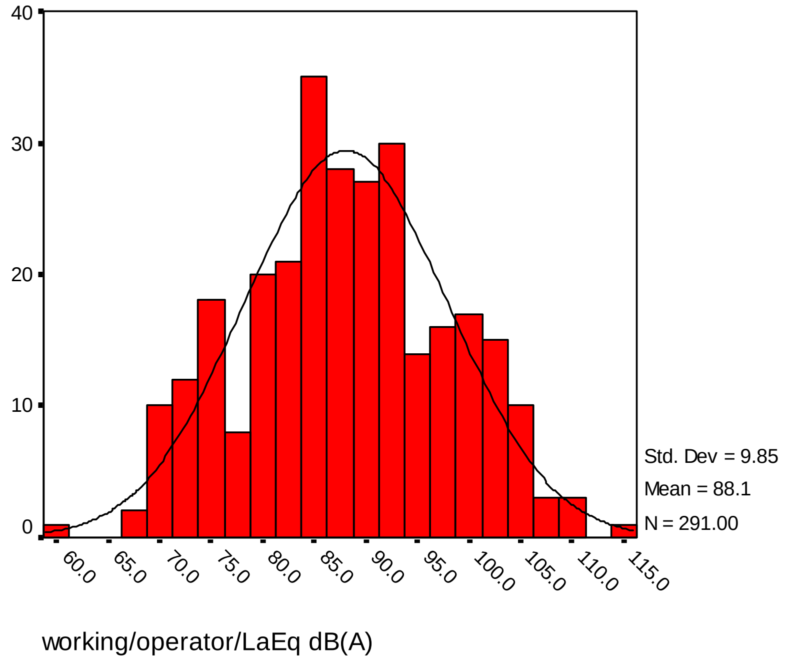
For the major machinery / activities measured in this study, all but two (dairies and cabined tractors) have an average (L_{Aeq}) above 80dB(A). The loudest items are firearms, chainsaws, irrigation pumps, circular saws and bulldozers, with average noise levels at the ear of the operator being over 99dB(A). Angle grinders, augers, pigs and uncabined tractors, all have averages above the 90dB(A) level.

There is also a middle group, with averages in the 85-90dB(A) range. These are represented by cotton module presses; air compressors (although there is a significant outlier in this group); four-wheeled motorcycles (ATV's); shearers, farm trucks and harvesters. Packing shed workers and cotton picker noise levels were between 80 and 85dB (A). However, radios and the long hours associated with operating cotton pickers, introduce other significant variables (see below).

Overall, the mean and range of noise levels for the different machinery types show that much of the on-farm machinery and the common activities associated with machinery are real noise hazards for the operator (over 85dB level). This point is further highlighted on examination of the overall distribution of noise levels for the study sample in Fig 3. This may be interpreted as simply illustrating the frequency of particular noise levels for this sample. However, given the context that "all available noisy equipment" was measured on each farm, it does show that the majority of 'noisy' equipment on the farms operated in the region of 85dB(A) to less than 95dB(A).

Question:	What were the most common noise levels encountered for operators using/during 'noisy' farm machinery and activities?
Answer:	The most common noise levels encountered were in the range from 85dB(A) to 95dB(A)
Implication:	Many common farm activities/machinery are real noise hazards.

Figure 3. Working/operator/L_{Aeq} measurements, all machinery (excluding firearms)



Variable Operating Conditions

Weather conditions

The impact of gusty wind conditions was only apparent on the days when horticultural farms in Queensland were visited. On these days, a 3dB difference was noted in sound levels during wind gusts compared to when calm, due to the effect of wind on the microphone of the sound meter. In these cases, the most "sheltered" measurement was recorded as being the most appropriate.

Idle vs. working revolutions.

Idling noise levels were in excess of 85dB(A) for small engines (eg. irrigation pumps, augers); workshop tools (angle grinders, circular saws); bulldozers and chainsaws. Perhaps with the exception of individual preferences with the use of the chainsaw, these items were idle for relatively short periods, with the noise intensity of the working tool overshadowing the significance of the idling phase.

Empty vs. full

Four augers were measured whilst empty, as the study was undertaken out of the main grain moving season. Many farmers explained that the augers are actually a little "quieter" when moving grain, as there is less metal on metal reverberation and rattle. This explanation is supported when the average of these empty augers {96dB(A)} was compared to the average of full augers moving grain or fertilizer as shown in Table 2 {93dB(A)}. For these reasons, it was decided to exclude these four from the pooled data as they do not reflect typical operating use.

Engine vs secondary implements

'Secondary' implements and attachments such as ploughs and seeders, were powered by the primary engine and were comparatively further away from an operator in a cabin. There is a 6dB decrease in sound level for each doubling of distance beyond the first metre (AS 2659.1-1988.21). Thus, inside cabined equipment, sound originating from secondary implements did not appear to affect the sound level received at the ear. This supported the relevance of measurements for machinery under 'working revolutions' where a secondary implement was not attached.

Some farmers commented that in a cabined machine, a secondary towed implement often affected the tone of the engine, as opposed to its loudness, as it contributed to power demand on the engine. This discriminatory difference in the nature of the sound assists the farmer to recognise any problems with the machinery's operation. It has been suggested by farmers to the researcher (and others), that this is a common reason for resisting the use of hearing protection. That is, that hearing protection will prevent the operator from hearing the subtle differences in the characteristics of the sound from the machinery's operation.

The presence of a secondary implement, however, had a much greater bearing upon noise levels when the operator has a window/door open, as on an un-cabined machine, or on the ground / adjacent to a secondary implement (particularly PTO driven implements such as feed-mills). This is due to the closer /unprotected proximity to the secondary implement, which renders its contribution to noise levels as much more significant and in some cases, the primary noise source.

Radio vs. no radio

A significant variable with regard to operating conditions was the presence of a radio for cabined machinery, and in sheds (eg. shearing sheds). Radios were found to affect the noise level received at the operator's ear by an average of 3dB (ranging from 1-5dB) in most circumstances (Table 2). These effects were tested for and are discussed in further detail below.

Louder and longer

The risk of hearing damage is a factor not only of the noise level, but of the time exposed to that level of noise. Considering the logarithmic nature of the decibel scale, each 3dB increase in sound level, results in a 'doubling' in the sound level (Australian Agricultural Health Unit N/96/1). This means that the exposure time needs to be halved in order to receive the same level of sound energy. Therefore, the introduction of factors that increase the noise level of machinery (radios, poor maintenance), will increase the risk of hearing damage and reduce the recommended exposure limits. Prolonged exposure time will also have a bearing on risk. Work days of 10 – 14 hrs duration, require an $L_{Aeq,8h}$ adjustment upward by 1dB. Over 14 hrs a L_{Aeq} adjustment of 2dB is necessary in considering risk of hearing damage (AS/NZS 1269.1:1998). Some of these factors are further discussed below.

The periodic nature of farming activities, and the variability in exposure to a particular item, presents some difficulty with quantifying 'typical' exposure times. For instance, a tractor might be used for 12-14 hrs/day during sowing, and not used for several weeks at quieter times. Farmers however, were asked to approximate to the best of their ability, a typical or 'not uncommon' period of exposure for a particular item within any one working day. This is useful in determining the relative risk of certain machinery/activities by comparing their actual period of use with the recommended limits for the individual farmer. It was decided not to pool this data, as average periods of use were highly variable both on and between farms, depending on need and season.

Influence of other factors on noise level

Age of machinery

It was hypothesized that the age of the machinery will have an impact on:

1. The wear and tear of the engine parts, producing more noise.
2. Any seals, mufflers and material insulating against noise initially provided, which may have been compromised under the influence of farm work.

In addition, as technology improves machinery design and engine efficiency, newer machinery tends to run quieter than their predecessors when they were new. Whilst testing of individual machines over time was not possible and not controlled for in this study, tests of significance for a general correlation between age of machinery and average noise levels were performed. A positive correlation was found to a statistically significant level ($P<0.01$) (Table 3). This lends support to the argument that the older pieces of machinery will have higher noise levels. It also suggests the importance of regular maintenance regimes for both the engine and upon noise reduction mechanisms (eg. exhaust, seals etc.) for older machinery in particular.

Question:	Is there a general correlation between noise level and age of machinery**?**
Answer:	Noise level of machinery is positively correlated with age.
Implication:	Age is an indicator of wear and tear - importance of regular maintenance to reduce operating noise.

Table 3. Relationships between age and average noise levels for all machinery

		Age of machinery	**Operator / L_{Aeq} dB(A)**
Age of machinery	Pearson Correlation	1.000	.242
	Sig. (2-tailed)	.	.000
	N	248	238
Operator / L_{Aeq} dB(A)	Pearson Correlation	.242	1.000
	Sig. (2-tailed)	.000	.
	N	238	299

** Correlation is significant at the 0.01 level (2-tailed).

Age of cabined tractors

As the largest sub-sample of machinery, the effect of age was tested for cabined tractors. An examination of the age of cabined tractors against average noise levels, revealed a statistically significant correlation (n=27; P<0.01). When the average noise levels for operators of two groups of cabined tractors were compared on the basis of older (10 yrs+) vs. newer tractors (0-9 yrs), it was found that the older group were on average 6dB louder than their younger counterparts. Table 4 presents a group average noise level four times higher for the older tractors. This difference was also statistically significant (t_{25}=3.85 P<0.001) Again, this supports the need for general maintenance regimes and the use of hearing protection with older machinery, especially when used for long periods of time.

Table 4. Relationship between age and noise levels in cabined tractors. Group Statistics

Tractor Age	**N**	**Mean L_{Aeq}dB(A)**	**Std. Deviation**	**Std. Error Mean**
0-9 yrs	19	74.09	3.59	.82
Over 10 yrs	8	80.70	5.10	1.80

T-test of significance between newer (0-9yrs) & older (10yrs+) tractors (t_{25}=3.85 P<0.001)

Question.	Do older cabined tractors (10yrs +) have higher noise levels in the cabin than younger cabined tractors (under 10 yrs)?
Answer:	Older cabined tractors had noise levels on average four times higher (6dB) than younger cabined tractors.
Implication:	Regular maintenance is especially important for reducing noise in older cabined machinery and hearing protection should be considered when using these over long hours.

Radios and cabined machinery

It is assumed that the presence of a radio will increase noise levels received at the operator's ear. If a radio does affect noise levels, what is the average size of this effect and is this significant? For cabined tractors fitted with radios, noise levels were compared with and without radio noise. There was a 3-5dB increase in the noise level received at the operator's ear after the radio had been turned on (Table 2). A t-test for this difference was performed and found to be highly significant (t_{23}=5.67, P<0.001). As mentioned previously, an average increase of 3dB will double the level of the noise in the cabin, due to the logarithmic nature of the decibel scale. This suggests that to 'drown out' machinery noise with a radio, the noise level in the cabin needs to be approximately doubled (3dB increase). Other cabined machinery showed similar effects, with cotton pickers, grain and sugarcane harvesters showing increases of 1-5dB in noise level when the radio was turned on (Table 2).

For machinery that has a L_{Aeq} under 80dB(A), as is the case with 'younger tractors' under 10 yrs, {mean L_{Aeq} of 74 dB(A)} it is perhaps not significant with regards to safe exposure periods. This is because the addition of a radio still does not place the operator within a borderline exposure zone {82 - 85dB(A)}. However, the radio does become significant for 'older tractors' over 10 yrs, {mean L_{Aeq} of 81dB(A)}. The implication is that for older machinery with noise emissions bordering at around 82-85dB(A), the addition of the radio will place the operator over the recommended 85dB(A) / 8 hr exposure limit. This will halve the recommended exposure time, once the 85dB(A) limit is reached.

Longer working hours, common on farms, will also impact upon noise exposure. Shifts of 10hrs +, which are common during times of peak farm activity, require an adjustment to allow for the longer exposure (AS/NZ 1269.1:1998). For example, a 14 hr shift will attract a 2dB adjustment in addition to the measured $L_{Aeq,8h}$. The following provides a scenario of these cumulative effects

Example: Cabined tractor – 12 years old.

Working/operator L_{Aeq} (no radio)	82dB(A)	8 hours^{+} exposure limit
Add radio	4dB	
Used 14 hrs in sowing	2dB	Adjustment for long hours exposure
Effective exposure over shift	88dB(A)	
Risk management equivalent:	**4 hours recommended exposure limit** (without hearing protection	

Question:	Does having a radio playing significantly increase the noise level within cabined machinery?
Answer:	Playing the radio approximately doubles the average noise level within the cabin.
Implication:	This becomes significant for cabined machinery operating around/over 85dB(A), whereby turning the radio on will then half the allowable (safe) exposure time without hearing protection. This is more likely to be the case for older machinery and over long hours of peak activity.

Radios and shearing sheds

Shearing sheds are an environment where the radio plays an important role in attempts to 'drown out' machinery noise and relieve workers with music and news. In this study, seven sheds were visited, all having electrically generated shearing units, which are quieter than their diesel (belt driven) counterparts. There were significant local variations within the shed environment. Some sheds did not use a radio; some shearers were a lot closer to the radio than others. For sheds where localised effects were investigated more closely (n=2), noise levels at the ear closest to the handpiece (primary noise source), was 2- 3dB higher than the opposing ear, presumably due to 'head shadowing' effects, as described by Clark (2002). The orientation of the shearers with respect to the off-hand/ear meant that this ear was generally closest to the radio. Thus, the noise level at both ears was approximately the same once the radio was playing.

Question:	Does having a radio playing significantly increase the noise level for shearers?
Answer:	For shearers, the average increase in noise level due to the radio was 2 dB (almost double) for the ear away from the handpiece, but had no noticeable effect on noise levels at the ear closer to the handpiece.
Implication:	Further work needs to be undertaken to explore this phenomenon

Similar localised effects of head-shadowing were noted in tractor cabins. For consistency, measurements before and after radios were turned on, were taken at the auricle of the same ear. Clark (2002) suggests, however, that despite possible asymmetrical locations of a continuous noise source, sound reverberation and head movement associated with the activity will result in a "similar exposure bilaterally". The only exception suggested by Clark that might be applicable to the farmer's situation, would be the unilateral exposure and hearing loss which occurs in shooters (Clark. 2002).

Cabins vs. no cabins.

Cabins on tractors reduce the amount of noise that the operator receives when in the cabin. The mean L_{Aeq} for cabined tractors (no radio) was 76dB, as opposed to 92dB for uncabined tractors (Table 2), a difference of 14dB. A t-test for this difference was found to be highly significant (t_{54}=12.96 $P<0.001$). Noise levels were also compared for three operating cotton pickers with the cabin door closed, and partly open. It showed an increase of 2-5dBs, approximately doubling the cabin noise level. As the average noise level for cotton pickers was 81dB, a 2-5dB increase can reduce safe exposure times to less than 8 hrs. It is not uncommon for the pickers to operate for 10–12 hour shifts.

As a noise reduction measure, enclosed cabins are a very effective design option. This has implications for choice of equipment when purchasing tractors and other cabined machinery (eg. harvesters – cane, grain, and cotton). It also has a bearing on engineering design for other machinery which may be amenable to having a cabin fitted (eg. bulldozers, cotton module presses). Cabin enclosures need to be adequately sealed and maintained to have optimal effect.

Question:	Do cabins make a significant difference to the noise levels at the operators ear?
Answer:	The noise level of uncabined tractors were on average 14dB louder than cabined tractors. Noise levels in the cabin increased by 2-5dB in cotton pickers when cabin doors were partly open.
Implication:	Cabins on machinery with maintained seals are an effective way to reduce noise levels for operators. Hearing protection should always be considered for uncabined machinery.

Others in the farm workplace

The position of any onlookers or any other persons who might assist with a farm activity was identified by the participating farmer in the context of their own farming operation. In many cases, others were not involved. This reflects the general nature of the farms visited being predominantly family farms, often operated with few if any employees, apart from assistance which may be afforded / required at peak activity times.

People assisting or onlooking were generally further away from the primary noise source than the operator. However, sometimes these 'others' were not protected by the cabin of large machinery, such as those servicing equipment in the field at grain and cotton harvest times (Table 2).

A major source of concern is for those assisting with woodcutting (ie. where a chainsaw is in use). Farmers reported that this was predominantly carried out by a family member such as a partner or child. Typical noise levels at the ear of persons helping to stack wood around chainsaws were around 96dB(A). This activity would therefore pose a significant risk to the hearing health of the person, especially if the activity was to exceed ½ an hour in any one day. The risk to children involved in this activity without the use of hearing protection is quite high. Although measurements for 'others' for firearms were not taken, the practice of 'spot-lighting' for vermin with children adjacent to the shooter in vehicles, also suggests this is a serious farm-noise hazard for young people on farms.

Family members are also likely to be involved with lawn mowing using ride-on mowers. These produce noise levels similar to an uncabined tractor averaging 92dB(A) in this sample (Table 50) and precautions need to be taken accordingly (eg. use of hearing protectors, reduce exposure time).

Other activities which are a likely to be a hazard to other workers / onlookers are workshop tools, and around augers and large machinery at harvest time. Workers may experience noise levels around grain harvesters, cotton pickers and module presses from 85dB(A) to 93dB(A). Whilst this exposure is usually not of a constant nature, the cumulative effects of several noise sources over the day for long hours (eg. 12-14hr shifts), can mean the person's ear does not have enough recovery time before the next consecutive 'long day'. These conditions may last for 3 – 6 weeks in a row (eg. cotton season - 42 days, grain harvest season - 21 days / 12 hr day's straight).

Question:	What activities place other people on the farm at most risk of noise injury?
Answer:	Accompanying shooters (firearms) and stacking wood (chainsaws) present the greatest risk, particularly to family members. Being in workshops and in the field at harvest time over long hours is also hazardous.
Implication:	Avoiding the noise, reducing exposure time and use of hearing protection should be considered by others in the vicinity of noisy activities.

Key noise hazards on the farm

The variety of different noise hazards possible within a day and the diverse nature of farming with peak vs. quieter periods for particular activities are characteristic of the variability of noise exposure in the farming context. The cumulative exposure to many different noisy activities within any given day must be considered, when assessing overall noise exposure risk. For example, a farmer may muster stock for an hour on an all terrain vehicle (ATV), and then plough a paddock on an uncabined tractor for 5 hours. This might be followed by a session in the workshop repairing a gate before cutting wood with a chainsaw for the evening house fire. Many such activities pose a threat to the hearing of farmers and others on the farm. However, there are certain characteristics of particular machinery, remembering its use is within this wider farming context, that warrant particular attention. By the nature of their use, different categories require a different emphasis with regard to the prevention of noise injury and health promotion interventions.

Firearms

Firearms are a major noise hazard on the farm. The potential for instant as well as cumulative noise injury without the use of hearing protection is a major concern. Firearms are often used opportunistically / periodically on farm or alternatively, are used recreationally. The use of firearms without hearing protection exceeds occupational health and safety regulatory standards.

Consideration of exposure time is not necessary to determine the relative risk, as every shot is a significant noise event. Due to the logarithmic effect of the decibel scale, the comparative sound energy emitted by a single shot from a firearm at 140dB(C) is equivalent to almost a full week of continuous exposure at 90dB(A) (Clark 2002). Because every shot is in the range beyond 140dB(C), others accompanying shooters are also at high risk, as the 6dB decrease in sound level with doubling of distance, has little effect given the initial magnitude of the shot and the relative closeness of onlookers to the shooter.

Firearms therefore, present an extremely hazardous threat to the hearing health of farmers and others including children. Young farmers are particularly at risk given their tendency to engage in on-farm recreational shooting. Firearms represent a particular challenge with regard to their appeal to young males who are not always amenable to traditional health promotional approaches / advice (Merton in Peterson.1996). Health education strategies for younger people should target risky behaviours and the thinking processes that go with these practices, as much as the factual information.

The unprotected use of firearms by farmers and others on farm including children should be afforded a high priority in health and safety promotion interventions. Use of suitable hearing protection whilst shooting must be strongly encouraged to protect the hearing health of younger farmers in particular.

Uncabined tractors

When compared to the typical periods of use reported, another highly significant hazard is the uncabined tractor. With an average working L_{Aeq} of 92dB(A), unprotected use beyond 2 hours would not be recommended. However, the average / typical period of exposure reported by the farmers in this sample was 5 hours. Whilst in most cases the use is not daily, uncabined tractors pose as a high risk to the hearing of farmers, the more often it is used without hearing protection beyond 2 hours in any given 8 hour period.

"Long day" cabined machinery with radios

Other noise hazards which may be less obvious to the farmer are cabined machinery which is operated for long hours. Cotton pickers, grain and sugarcane harvesters and tractors with cabins are often used for long hours. This places the worker at greater risk of hearing damage, considering the dB adjustment mentioned earlier, which accounts for threshold shift in hearing and the reduced recovery time between shifts. (AS/NZS 1269.1:1998).

Most cabined machinery measured was fitted with a radio. As noted earlier, on average this doubles the noise level within the cabin. As one operator explained, it is not unusual on long days to turn up the volume of the radio (2-5dB) as the shift progressed, to keep him 'alert'. Thus the combined effects of long shifts and radios can place the operator at risk. Whilst this may not be significant in a new piece of equipment, it is likely to be more significant as the machinery ages.

Field workers around augers and heavy machinery are also at risk, although these are not generally near the engine whilst it is at working revolutions. An exception to this may be in the case of cotton harvesting, with fieldworkers on the ground near module presses when pickers turn at the end of a row.

Workshop tools

This group are also high risk noise injury hazards due to their more obvious high noise level {90-100dB(A)}. However, shorter periods of use (Table 2) and infrequent exposure (eg. "Once a month"), mean that in some cases, these may be less hazardous than the "long day" machinery. The more apparent need to use of hearing protection in workshops may also be more easily identified by farmers. However, for some there may be the "only use it for a minute" temptation to counteract this effect. Periods of exposure beyond 15 minutes for workshop tools present a high probability of risk of hearing damage. This group of equipment is also a hazard to other people in and around the workshop.

Small motors (pumps, augers and chainsaws)

If used unprotected, chainsaws are a high risk to both the operator and to family members /others who assist with stacking wood. Augers and other small motors such as pumps and brush cutters are also implements which are used for short periods, however have a high dB rating that requires vigilance with the use of hearing protection and minimising exposure time.

SUMMARY OF FINDINGS

Work environments which require raising the voice to communicate at a distance of 1 metre, are above safe working levels (Australian Agricultural Health Unit.1997). This is a useful indicator in the absence of formal noise measurements, and gives an indication of when noise reduction or avoidance strategies should be considered. These include reducing noise at the source / during transmission (eg. engineering controls – buy quieter, regular maintenance, modify design - cabins); strategies to reduce exposure (eg. avoid, rotate tasks); the use of hearing protection.

Common noise hazards identified through this study that produce excessive noise included:

- Firearms
- Uncabined tractors
- Chainsaws
- Workshop tools
- Small motors (eg. augers, pumps, lawnmowers)
- Manual – fed piggeries
- Shearing sheds
- Heavy machinery – particularly older field machinery used for long hours such as cabined tractors, harvesters (grain, cotton, and sugar cane), and cotton module presses.

To assist in noise management, exposure times must be considered in assessing risk of hearing damage when hearing protectors are not used. Table 2 summarises the approximate exposure limits based on measurements taken in this study for major machinery types. When typical exposure times and the context of use are examined, the differing characteristics of firearms; uncabined tractors; workshop tools; chainsaws; small motors; and field machinery comes into play.

The concept that a low level of noise can present a significant hazard to the operator depending on the period of operation, needs to be emphasised and developed so that users fully understand the potential noise hazard. When working with noisy equipment, a machine that operates at 105dB(A) or 110dB(A) sounds significantly louder than one that operates at 85dB(A) or 90dB(A). An operator is much more likely to take precautions with an obviously more hazardous piece of equipment (very noisy) than one not so (quieter), eg. wear earmuffs or earplugs. However, quite often the less noisy item is used for longer periods than a noisy piece of equipment, for example a tractor compared to a chainsaw. This increased time of use makes the less noisy item much more of a potential hazard. It is particularly important considering there are more "less" noisy machines than "very" noisy machines (Figure 3).

Age of machinery was positively associated with increased noise level, most likely related to improved technology and general wear and tear. This highlights the importance of regular maintenance regimes, especially for older machinery, in order to minimise noise.

The presence of a cabin or insulating barrier reduces noise significantly by interrupting the transmission path. Cabin design and insulation materials will have a positive effect. Some machinery has cabined and uncabined alternatives. Buying 'quieter' at the time of purchase, or engineering cabins/barriers on current machinery / in sheds where possible (eg. cotton module presses, packing and shearing sheds) is thus an effective noise reduction measure.

The use of a radio was found to play a role in field machinery and in older cabined tractors; effectively doubling the noise level. Limiting the period of use of these in certain circumstances, or maintaining the volume at a level just adequate to 'drown out' equipment noise will assist in reducing overall risk of hearing damage. The effect of radios on shearers in shearing sheds needs further exploration.

During peak activity times, tractors and other field machinery are often used for long hours, which reduce the noise levels considered to be safe. This is related to the human hearing mechanism as well as to fatigue which encourages the use of louder radios. Limiting shift hours or rotating persons involved in operating the machinery, would be possible noise reduction strategies.

Other people in the farm environment are also at risk of sustaining noise injury, especially around firearms, and chainsaws. Workshop tools, small motors and operating field machinery are also potentially hazardous if around them for extended periods. Avoidance measures and the use of hearing protection in these circumstances will help to protect the hearing of farm workers and farm families.

The most extreme noise hazard insofar as the loudness of noise, was the use of the firearm without hearing protectors. This can instantly damage the hearing of both the shooter and those in the immediate vicinity.

When typical periods of use are examined against recommended periods of use, uncabined tractors remain a very high risk to the hearing of farmers. Particular factors relating to noise level and period of use also have a bearing on the other major farm hazards, which are discussed in this report. This impacts upon decisions regarding the best strategies to use in reducing farm noise, and in the appropriate use of hearing protection. It is hoped that a greater awareness of these factors through dissemination of this information, will contribute to the quality of programs aimed at preventing noise injury amongst farmers, farm workers and farm families.

RECOMMENDATIONS

1. Consistent with general precautionary principles, it is highly recommended that noise reduction strategies and the use of hearing protectors be addressed in all farm environments where it is necessary to raise one's voice to be heard at a distance of 1 metre.

2. This report be used to update and/or inform:

    - Guidance material on noise as part of the Managing Farm Safety Program
    - Take home material and advice to participants at field day screening programs
    - A National Noise Injury Prevention Strategy for the Australian Farming Community

3. High priority is afforded to promoting strategies for the protection of hearing of farmers and farm families from firearms, chainsaws and uncabined tractors.

4. All farm noise hazards identified in this study are addressed within a comprehensive approach to the assessment and management of farm noise.

REFERENCES

Australian Agricultural Health Unit. 1996 *Rural Noise & Hearing Loss*. Ag-Fact sheet N/96/1

Australian Centre for Agricultural Health & Safety. 1997. *Guidance note 4. Noise on Farms*. Australian Centre for Agricultural Health & Safety, Moree.

Australian Standard 1259.2-1990 *Acoustics-Sound Level Meters Part 2: Integrating-averaging.* Standards Australia. Homebush

Australian Standard 2659.1 – 1988 *Guide to the use of sound- measuring equipment Part 1 – Portable sound level meters*. Standards Australia. Homebush

Australian / New Zealand Standard 1269.1:1998. *Occupational noise management Part 1: Measurement and assessment of noise immission and exposure.* Standards Australia. Homebush / Standards New Zealand. Wellington

Franklin RC, Challinor K, Depczynski J, Fragar LJ In press. *Noise exposure, hearing protection and noise injury in young adult farmers*. Australian Centre for Agricultural Health & Safety, Moree

Farmsafe NSW 1994. *NSW Rural Hearing Conservation Strategy*. Farmsafe NSW, Moree.

Clark, W.W. 2002. *Five myths in assessing the effects of noise on hearing.* www.Audiologyonline.com 113-3-02

Clark, W.W & Bohne, B.A 1999. Effects of noise on hearing. *JAMA 281*,17:1658-1659

ISO 1999 *Acoustics – Determination of occupational noise exposure and estimation of noise induced hearing impairment.* International Organisation for Standardization

National Occupational Health and Safety Commission *Occupational Noise: National Standard [NOHSC:1007(2000)]*. National Occupational Health and Safety Commission. Canberra

National Occupational Health and Safety Commission *Occupational Noise: National Code of Practice [NOHSC:2009(2000)]*. National Occupational Health and Safety Commission. Canberra

Petersen, C. 1996. *Looking Forward through the lifespan: Developmental Psychology*. Prentice Hall. Sydney

Sarantakos, S. 1998. *Social Research* (2nd edn). Macmillan Education. Australia. South Yarra

Williams, W., Forby-Atkinson, L., Purdy, S. and Gartshore, G. (2002) Hearing loss and the farming community. *Journal of Occupational Health and Safety – Australia and New Zealand 18*(2),181-186.

APPENDIX 1

All machinery types – range, central tendencies for age of machinery, L_{Aeq}, and L_{Peak} noise levels for operators and some others. All figures have been rounded to the nearest whole number.

1. Agrivac

Table 5. Agrivac, age L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 agrivac	4	97	107

2. Air compressor

Table 6. Air compressors, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of compressors	8	10	10
Mean	15	86	110
Median	15	85	108
Std. Deviation	7	14	13
Minimum	5	71	89
Maximum	25	115	133

3. Air gun

Table 7 Air guns, age L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of airguns	2	2	2
Mean	4	95	120
Median	4	95	120
Std. Deviation	2	10	10
Minimum	2	88	113
Maximum	5	102	127

4. All terrain vehicles

Table 8 All terrain vehicles, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of ATV's	13	13	13
Mean	7	86	108
Median	6	85	110
Std. Deviation	4	4	4
Minimum	1	81	102
Maximum	12	94	115

5. Angle grinders

Table 9. Angle grinders, age, L_{Aeq} and L_{Peak} results of operators and others

	age of machinery (years)	Operators L_{Aeq} dB(A)	Operators L_{Peak} dB	Others L_{Aeq} dB(A)	Others L_{Peak} dB
No. of grinders	11	12	12	6	6
Mean	9	98	116	90	107
Median	5	98	115	90	107
Std. Deviation	9	3	3	3	2
Minimum	1	93	111	85	104
Maximum	25	104	122	93	110

6. Augers

Table 10. Augers, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of augers	11	12	12
Mean	13	93	111
Median	7	93	110
Std. Deviation	12	7	5
Minimum	1	79	104
Maximum	35	102	120

7. Bench grinders

Table 11. Bench grinders, age, L_{Aeq} and L_{Peak} results of operators and others

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB	working/other L_{Aeq} dB(A)	working/other L_{Aeq} dB
No. of grinders	5	6	6	5	5
Mean	13	99	115	89	107
Median	8	99	116	90	109
Std. Deviation	13	7	5	8	6
Minimum	3	91	107	80	97
Maximum	35	108	122	98	112

8. Blower (horticulture)

Table 12. Blower, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB(A)
1 blower	6	93	119

9. Broccoli Transplanter

Table 13 Broccoli transplanter, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 broccoli transplanter	1	83	124

10. Brush cutters/ Whipper snipper

Table 14 Brush cutters / whipper snipper, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of cutters/snippers	3	4	4
Mean	5	99	114
Median	2	100	115
Std. Deviation	6	4	4
Minimum	0	93	109
Maximum	12	102	118

11. Bulldozers

Table 15. Bulldozers, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of bulldozers	6	6	6
Mean	28	99	122
Median	25	98	123
Std. Deviation	18	2	7
Minimum	8	97	113
Maximum	50	103	133

12. Chainsaws

Table 16. Chainsaw, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	Operators L_{Aeq} dB(A)	Operators L_{Peak} dB	Others L_{Aeq} dB(A)	Others L_{Peak} dB
No. of chainsaws	10	11	11	6	6
Mean	11	106	122.	96	113
Median	8	106	123	98	115
Std. Deviation	7	3	3	4	5
Minimum	5	100	116	88	104
Maximum	20	110	126	99	116

13. Chicken shed

Table 17 Chicken shed, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
2 positions, 1 shed	2	2
Mean	71	92
Median	71	92
Std. Deviation	2	3
Minimum	69	90
Maximum	72	94

14. Circular saws

Table 18. Circular saw, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of saws	10	12	12
Mean	12	99	114
Median	8	100	115
Std. Deviation	6	3	6
Minimum	5	94	98
Maximum	20	104	121

15. Cool room

Table 19. Cool room, age, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of coolrooms	5	5
Mean	85	105
Median	86	105
Minimum	75	101
Maximum	92	111
Std. Deviation	6	4

16. Cotton module presses

Table 20. Cotton module press, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	Operators L_{Aeq} dB(A)	Operators L_{Peak} dB	Others L_{Aeq} dB(A)	Others L_{Peak} dB
No. of presses (14)	12	14	14	20 positions	20 positions
Mean	12	86	115	83	114
Median	12	86	116	83	114
Std. Deviation	9	3	3	4	5
Minimum	2	83	107	77	105
Maximum	35	92	120	89	124

17. Cotton Pickers

Table 21. Cotton pickers, age, L_{Aeq} and L_{Peak} results for operators and others

	age of machinery (years)	Operators L_{Aeq} dB(A)	Operators L_{Peak} dB	Others Servicing picker L_{Aeq} dB(A)	Others Picker turning L_{Aeq} dB(A)
No. of pickers	8	6	6	5	2
Mean	5	81	110	84	94
Median	5	81	111	88	94
Std. Deviation	4	4	2	6	2
Minimum	1	75	107	75	92
Maximum	10	88	112	89	95

18. Dairies (herringbone 24 bay)

Table 22. Herringbone dairies in pit, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of positions in pit (2 in each of 5 dairies)	10	10
Mean	73	100
Median	73	100
Std. Deviation	3	4
Minimum	78	107
Maximum	10	10

19. Dog bark

Table 23. Dog bark, distance and L_{Peak} results

	working/operator distance	working/operator L_{Peak} dB
No. of dogs	2	2
Mean	3	104
Median	3	104
Minimum	2	104
Maximum	3	105

20. Drill

Table 24 Drill, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 Drill	30	88	107

21. Feedmills/mixers

Table 25. Feedmills / mixers, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	Operators L_{Aeq} dB(A)	Operators L_{Peak} dB	Others L_{Aeq} dB(A)	Others L_{Peak} dB
No. of mills/mixers	4	4	4	3	3
Mean	19	91	109	84	103
Median	20	90	108	84	102
Std. Deviation	13	4	4	<1	3
Minimum	6	87	105	83	101
Maximum	30	96	115	84	107

22. Firearms

Table 26. Firearms, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Peak} dB
No. of firearms	10	10
Mean	17	140+
Median	15	140+
Minimum	1	135
Maximum	40	140+

23. Forklifts (non-electric)

Table 27. Forklifts, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of forklifts	4	4	4
Mean	16	84	111
Median	18	85	110
Std. Deviation	6	4	7
Minimum	8	80	103
Maximum	20	88	121

24. Front-end loaders

Table 28. Front-end loaders, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of loaders	1	2	2
Mean	12	81	113
Median	12	81	113
Minimum	12	80	111
Maximum	12	82	116
Std. Deviation		2	3

25. Generators/workstations

Table 29. Generators/workstations, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of generators	4	5	5
Mean	4	85	105
Median	4.	85	105
Std. Deviation	3	6	4
Minimum	1	79	99
Maximum	6	92	111

26. Grain elevator

Table 30. Grain elevator, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 elevator	81	102

27. Groupers

Table 31. Groupers, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of groupers	3	4	4
Mean	6	90	113
Median	5	91	111
Std. Deviation	4	3	6
Minimum	3	86	107
Maximum	10	92	121

28. Hammermill

Table 32. Hammermill, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 hammermill	8	92	111

29. Harvest-aids

Table 33. Harvest-aids, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of harvest-aids	1	2	2
Mean	25	78	121
Median	25	78	121
Minimum	25	77	120
Maximum	25	79	122
Std. Deviation		1	1

30. Harvesters

Table 34. Harvesters, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of harvesters	7	7	7
Mean	20	83	111
Median	11	87	112
Std. Deviation	19	11	7
Minimum	5	70	102
Maximum	50	95	120

31. Homogeniser

Table 35. Homogeniser, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 homogeniser	2	87	101

32. Lettuce transplanter

Table 36. Lettuce transplanter, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of transplanters	1	2	2
Mean	2	85	114
Median	2	85	114
Minimum	2	85	113
Maximum	2	85	115
Std. Deviation		1	2

33. Metal on metal

Table 37. Metal on metal, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of situations	2	3
Mean	103	131
Median	103	129
Minimum	101	124
Maximum	104	141
Std. Deviation	3	9

34. Milk vats

Table 38. Milk vats, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of vats	3	3
Mean	73	101
Median	72	102
Minimum	71	98
Maximum	75	103
Std. Deviation	2	3

35. Mini-tractor

Table 39. Mini tractor, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of tractors	2	2	2
Mean	9	84	112
Median	9	84	112
Std. Deviation	2	5	9
Minimum	7	81	106
Maximum	10	88	118

36. Motorbikes

Table 40. Motorbikes, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of motorbikes	2	2	2
Mean	3	81	103
Median	3	81	103
Std. Deviation	2	8	6
Minimum	2	76	99
Maximum	5	87	107

37. Packing/processing sheds – worker positions (horticulture)

Table 41. Packing/processing sheds – worker positions (horticulture) L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of worker positions in 8 sheds	28	28
Mean	80	104
Median	81	105
Std. Deviation	5	6
Minimum	68	90
Maximum	88	117

38. Piggeries – auto fed
a. around sheds

Table 42. Pig sheds – auto fed , around sheds (1 piggery, 6 positions), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of shed positions	6	6
Mean	72	104
Median	72	104
Std. Deviation	5	2
Minimum	67	100
Maximum	80	106

b. automatic feeding pump (electric)

Table 43. Pig sheds – auto fed , at automatic feeding pump (1 shed), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 auto feeder	60	90

39. Piggeries – manual fed
a. manual feeding (around sheds)

Table 44. Pig sheds – manual feeding (1 piggery, 3 shed positions), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of shed positions	3	3
Mean	87	114
Median	92	115
Std. Deviation	11	7
Minimum	74	107
Maximum	94	121

b. handling suckers

Table 45. Pig sheds – manual fed, handling suckers (1 piggery, 1 shed), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 shed	109	127

40. Post driver

Table 46. Post driver, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 driver	104	135

41. Processing plant (nut) – worker positions

Table 47. Processing plant (nut), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of positions in 1 plant	4	4
Mean	84	104
Median	84	104
Std. Deviation	<1	<1
Minimum	83	103
Maximum	85	104

42. Pump - irrigation

Table 48. Pump - irrigation, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of pumps	5	7	7
Mean	17	100	120
Median	15	102	119
Std. Deviation	14	5	6
Minimum	4	89	112
Maximum	40	105	129

43. Pump - spray

Table 49. Pump - spray, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 spray pump	88	110

44. Ride-on mowers

Table 50. Ride-on mowers, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of mowers	4	6	6
Mean	4	92	112
Median	2	92	112
Std. Deviation	5	1	3
Minimum	1	90	107
Maximum	12	94	115

45. Seedling shed

Table 51. Seedling shed, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of positions in 1 shed	2	2
Mean	75	96
Median	75	96
Minimum	74	95
Maximum	76	97
Std. Deviation	2	1

46. Shaker (horticulture)

Table 52. Shaker (horticulture), age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 shaker	4	87	127

47. Shearing sheds

a. Shearing sheds – shearers

Table 53. Shearing sheds – shearers L_{Aeq} and L_{Peak} results

	Working/operator L_{Aeq} dB(A)	Working/operator L_{Peak} dB
No. of shearers in 7 sheds	15	15
Mean	86	105
Median	85	105
Std. Deviation	3	3
Minimum	81	99
Maximum	91	110

b. Shearing sheds – shed workers

Table 54. Shearing sheds – shed workers, L_{Aeq} and L_{Peak} results

	Working/operator L_{Aeq} dB(A)	Working/operator L_{Peak} dB
No. of shed workers in 7 sheds	11	10
Mean	80	105
Median	79	104
Std. Deviation	5	8
Minimum	75	93
Maximum	92	119

48. Sugarcane harvester

Table 55. Sugarcane harvester, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 harvester	4	86	114

49. Sweeper (horticulture)

Table 56. Sweeper (horticulture), age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 sweeper	1	86	121

50. Tractors with cabins

a. Tractors with cabins – all ages

Table 57. Tractors with cabins, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of tractors	27	30	30
Mean	7	76	104
Median	4	75	103
Std. Deviation	7	5	6
Minimum	1	68	93
Maximum	27	86	117

b. Tractors with cabins 0-9 yrs

Table 58. Tractors with cabins 0-9 yrs age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of tractors	19	19	19
Mean	4	74	102
Median	3	73	102
Std. Deviation	2	4	5
Minimum	1	68	93
Maximum	8	83	112

c. Tractors with cabins 10+ years

Table 59. Tractors with cabins 10+ years, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of tractors	8	8	8
Mean	16	81	109
Median	14	82	109
Std. Deviation	7	5	7
Minimum	10	72	97
Maximum	27	86	117

51. Tractors without cabins

Table 60. Tractors without cabins, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of tractors	28	26	26
Mean	20	92	113
Median	20	92	113
Std. Deviation	12	4	4
Minimum	1	83	107
Maximum	45	100	124

52. Trucks (farm)

Table 61. Trucks (farms), age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of trucks	10	11	11
Mean	24	85	110
Median	20	86	110
Std. Deviation	13	4	5
Minimum	5	79	102
Maximum	50	92	120

53. Vacuum pumps (dairy)

Table 62. Vacuum pumps (dairy), L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of pumps	4	4
Mean	84	103
Median	83	104
Minimum	81	98
Maximum	91	105
Std. Deviation	4	3

54. Washer – Waxer (gas) (horticulture)

Table 63. Washer – waxer (gas) (horticulture), age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
1 washer-waxer	15	83	101

55. Welder - portable

Table 64. Welder - portable, age, L_{Aeq} and L_{Peak} results

	age of machinery (years)	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of welders	1	2	2
Mean	20	91	111
Median	20	91	111
Minimum	20	90	106
Maximum	20	93	117
Std. Deviation		2	8

56. Yard work

Table 65. Yard work, L_{Aeq} and L_{Peak} results

	working/operator L_{Aeq} dB(A)	working/operator L_{Peak} dB
No. of yard work occasions	2	2
Mean	80	106
Median	80	106
Minimum	77	103
Maximum	82	110
Std. Deviation	4	5