# final report

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## Band Saw Resistant Glove- Design Concept Report

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# Abstract

The Australian Red Meat Industry is committed to removing and reducing risks to employees. One of the risks workers in the red meat industry face is saw blade injury ranging from minor cuts to loss of limbs. For some tasks it has been possible to remove operators away from band saws and remove the risk. However for other tasks operators are still required to work on band saws and are exposed to significant risk.

To reduce the risk to operators it was proposed that design and use of a saw blade resistant glove could be implemented, reducing the risk of injury to band saw operators, in meat processing plants and in retail butcheries.

This project was designed to approach the solution from a new direction: to utilise the services of two industrial design firms with their specialised rapid product development techniques to: understand the usage patterns of band saw operators, and then develop design concepts and/or models of personal protection (i.e.; such as gloves), utilising new materials and composites to provide: protection while offering the operator usage needs such as flexibility, ease of use and cleaning, and tactile control of the meat product.

This project will focus only on the personal protection device, as other more complex machine modifications (safety sensors, blade stoppers, restraint devices, etc) are being developed with other initiatives.

It was envisaged that design concepts would be evaluated by an industry panel, with the potential for further product development and prototype samples if initial results were encouraging.

# Executive summary

Two Industrial Design firms (Kennovations and Design & Industry) were briefed on the details of band saw preparation of carcass primal cutting and meat portioning, including a site visit to one of Australia's leading processors. The site visit which included an industry consultation session was used to identify typical industry operating procedures and design objectives. The two companies then entered into a competitive design phase, the results of these projects are to be presented to MLA for analysis - concepts deemed suitable may then be further developed in a subsequent project.

This report outlines the results of the Kennovations project. The results of the Design & Industry project may be available in a similar report but have been submitted separately to this document.

The Kennovations design concept was developed with a focus on three key objectives:
- Improving operator safety
- Retaining operator productivity
- Encouraging industry acceptance

Ongoing consultation with industry management and band saw operators was required in order to provide a solution that accommodated a range of design parameters. The design concept/s developed have the potential to be taken to prototype after more detailed research and further design assessment by industry representatives is complete.

# Contents

Page

**Executive summary** ..... **3**

**1 Background** ..... **5**

**2 Project objectives** ..... **6**

**3 Methodology** ..... **7**

3.1 Addressing the key factors of importance - Safety / Productivity / Industry acceptance ..... 7

3.2 Other factors of importance – Perceived lack of safety / Management factors / Operator factors ..... 7

**4 Results and discussion** ..... **8**

4.1 Existing design – Product overview ..... 8

4.2 Proposed design – Product overview ..... 11

**4.2.1 General description of product design process** ..... 11

**4.2.2 Material selections and functions** ..... 12

**4.2.3 Silicon / Polyurethane membrane** ..... 12

**4.2.4 Metallic polymer scales** ..... 13

**4.2.5 Design overviews** ..... 15

**5 Conclusions and recommendations** ..... **16**

5.1 Further development ..... 16

**6 Supplementary concept** ..... **17**

6.1 The Laser ‘Danger zone’ system ..... 17

**7 Appendices** ..... **21**

7.1 Guidelines on the selection and use of cut resistant gloves in the meat industry – Safer Industries ..... 21

7.2 WORK COVER NSW - Catalogue No. WC01356: Fact Sheet MANAGING RISKS ASSOCIATED WITH BANDSAWS IN THE RETAIL, MEAT, SEAFOOD AND POULTRY INDUSTRIES ..... 35

7.3 The Australian Meat Industry Council (AMIC) and WorkCover NSW – Bandsaw Safety Poster 3084[1] ..... 39

7.4 PPE Last Resort – Presentation by Chris Torley, Fletcher International WA ..... 40

7.5 Evaluation of Safety Gloves for Bandsaws, Peter Dowd, ANAGO 2003 .... 54

# 1 Background

The meat processing industry has been utilising a range of gloves for personal protection for many years. Several reports have examined the suitability of the gloves specifically highlighting some of the negative elements of the chain mail version[1]. Traditionally the gloves have been used during the boning process and have been very effective in protecting the users across a range of processes. With the continuing modernisation of factories an increase in the number of high powered band saws has resulted, and as such an examination of the suitability of this glove style for this specific processing role (band saw operations) is required.

Opinions on the suitability of existing chain mail gloves for band saw operation vary greatly from state to state, and in fact from factory to factory. Although the recognition of the risks associated with band saw use is generally universal[2], the acceptance of the chain mail gloves as a suitable form of protection is not. For example; NSW Work Cover meat processing guidelines do not encourage the use of the gloves[3]; however in in the processing plant visited during the project orientation it is mandatory to wear the glove during band saw operations. Acknowledging that the majority of personal opinions is heavily polarised towards the negative, suggesting the wearing of a glove of any type is definitely not suitable and inherently unsafe, operators in the visited processing plant are persisting with the glove with seemingly positive results. Interviews conducted during the project orientation suggest injury rates are continuing to improve. The positive nature of these results however is complicated by the fact that gloves are not the only form of personal protection and factories have continually improved OH&S procedures in order to reduce the risks of injury to band saw operators[4]. The improvements have been aimed at addressing factors such as operator fatigue, inexperience, and low concentration levels which also contribute to the likelihood of an operator receiving a band saw blade injury. Processing plants now consider safety to have many levels but ultimately in the event of an accident where the wearer is using a chain mail glove, management at the visited plant view the stainless steel chain mail glove as a valuable last line of defence.

[1] Guidelines on the selection and use of cut resistant gloves in the meat industry – Safer Industries
[2] WORK COVER NSW - Catalogue No. WC01356: Fact Sheet MANAGING RISKS ASSOCIATED WITH BANDSAWS IN THE RETAIL, MEAT, SEAFOOD AND POULTRY INDUSTRIES
[3] The Australian Meat Industry Council (AMIC) and WorkCover NSW – Bandsaw Safety Poster 3084[1]
[4] PPE Last Resort – Presentation by Chris Torley, Fletcher International WA

# 2 Project objectives

The primary objective of this project is to present a conceptual design for a protective glove aimed at improving the safety of band saw operators.

The report also presents a second, supplementary safety product concept which may be further developed in addition to, and separately from the glove. The product is not a wearable item of personal protective equipment but rather a modification of existing laser line technology.

The project research and resulting conceptual design(s) are intended to stimulate discussion within the industry and present feasible design directions for further development.

Both product concepts attempt to address the factors considered important by both industry and operators alike, and aim to be relatively low cost, incremental improvements on existing safety concepts.

# 3 Methodology

## 3.1 Addressing the key factors of importance - Safety / Productivity / Industry acceptance

It is proposed that the development of a glove concept that solely addressed the safety of the operator would result in a product deemed unsuitable by industry management. Such a product would be likely to adversely affect productivity due to the restraints placed on the operator in order to reduce the risks. Conversely, it is proposed that the current situation in most plants of operators not wearing a glove at all solely addresses the needs of the industry from a productivity standpoint and leaves the operator unnecessarily vulnerable to injury. Whilst the chain mail glove may in certain situations improve some of the safety issues it does not adequately satisfy the industry as a whole and has met significant resistance. Developing a new glove that addresses a range of issues for several parties would be most likely to gain industry support. Different plants and operators within the industry also have different requirements (e.g. the type of animal being processed i.e. Beef, Lamb, or Pork, the types of cuts being made i.e. portioning vs. tipping, the consistency in size of animal being processed, the rate of repetition of the cut type, the rate of cuts required in a given time etc.) and the proposed design should present an opportunity for customisation to each. It is very likely that no one glove design is likely to satisfy the entire market, so in order to gain acceptance across the industry the glove must tailor to a range of needs.

## 3.2 Other factors of importance – Perceived lack of safety / Management factors / Operator factors

Informal interviews with band saw operators from leading processing plants, and several internet sources[5] identify one of the most significant problems with protective gloves for band saw use is that an operator has a greater likelihood of being 'dragged in' to the blade in an incident if wearing a protective glove. It was not clear at the start of the project whether this perception of safety was a result of formal research or of general observations on band saw injuries in general, regardless of the glove type being worn. Research identified during the project, conducted by ShowABestGlove for the food industry in NZ indicates that the chain mail glove type does definitely represent a significant risk of increased or varied injury relative to wearing no glove at all[6]. This perceived lack of safety provided by the glove concept will be one of the most important factors in gaining industry acceptance.

Several other factors apart from safety and productivity will contribute to the success of any proposed design. The factors can be loosely separated in to two key areas: *Management focused factors* such as (but not limited to) the potential cost of product development, the upfront cost of each unit, maintenance procedures and costs such as laundering, reliability, versatility, hygiene risks: and *Operator focused factors* such as (but not limited to) comfort, weight, warmth, dexterity, tactile sensitivity. Some of these factors may be common to both groups and indirectly contribute to both safety and productivity.

[5] Guidelines on the selection and use of cut resistant gloves in the meat industry – Safer Industries

[6] Evaluation of Safety Gloves for Bandsaws, Peter Dowd, ANAGO 2003

# 4 Results and discussion

## 4.1 Existing design – Product overview

Although there are several variations on the standard chain mail glove the design principles are generally consistent across the majority of the product range. The key features and functions of a typical chain mail glove are shown in Figures 1 and 2 and described below:

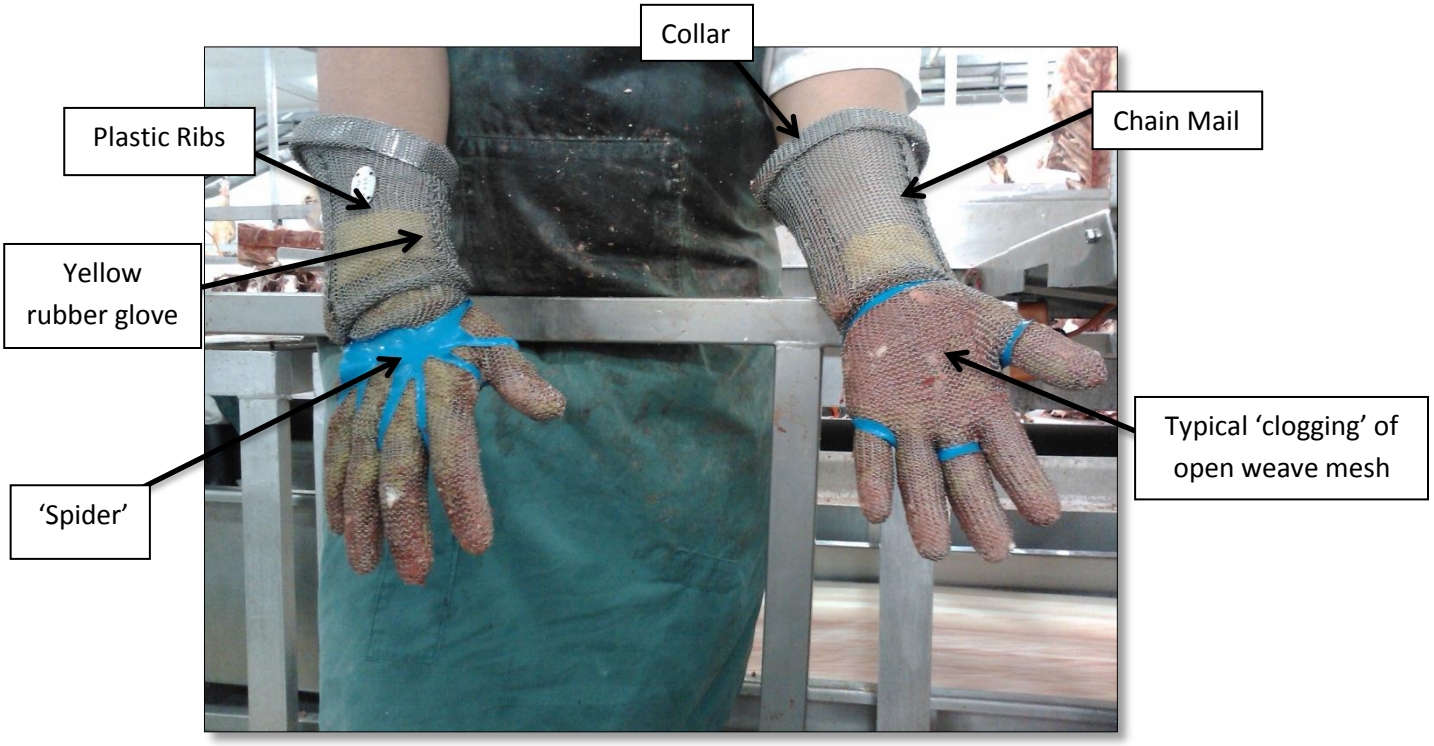


Figure 1 - Typical 'forearm length' Chain Mail Gloves (Source: Taken by Tim Phillips during project orientation 7.10.11)

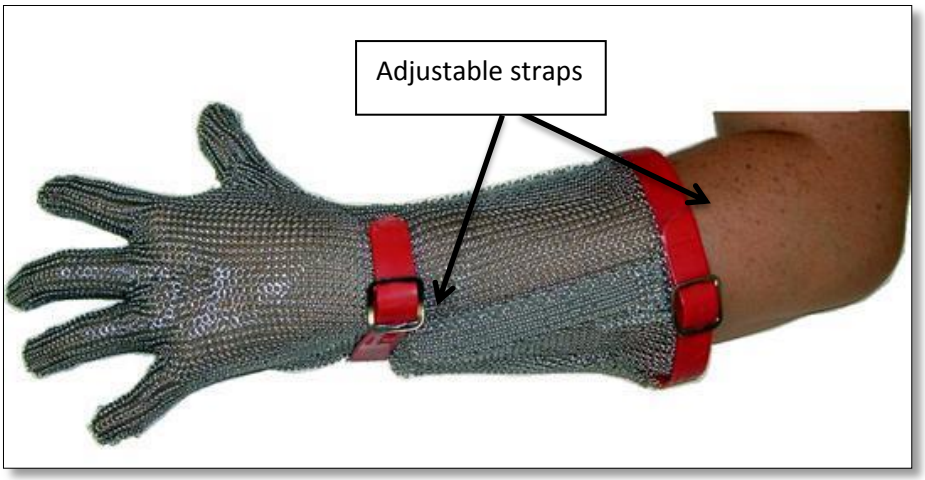


Figure 2 - Chain mail glove with adjustable straps

(Source: http://www.marssafety.com.au/catalogue.php?cID=b3ea8ece-f79c-4985-be6c-e8872f0694b7&pID=99fce5a7-98ee-a2e5-ba35-17caef126b62&pPrev)

1) Chain Mail - provides the main resistance to cutting. The glove is available in a range of sizes (XXS-XL). Lengths = Glove (or hand) only, forearm length, and full sleeve. Sleeve length is generally determined by the specific boning activity. Chain mail is made from stainless steel and is available in several gauges or diameters.
2) Plastic / Silicon ribs – provides structural rigidity to the sleeve, ensuring the glove stays up during use.
3) 'Spider' – plastic disposable tensioning device to ensure tips of glove are taught over fingers. The spiders will generally last about 1-2 weeks of daily use before disposal due to permanent deformation and lack of performance.
4) 'Rubber Glove' Operators will typically wear a standard yellow rubber glove beneath the chain mail to protect hands from hot water when sterilising boning knives. Operators may also wear an additional cotton glove under the rubber glove in order to provide insulation in refrigerated conditions.
5) 'Collar' – helps maintain glove form. Shown here as a stainless steel ring. Some versions are available as adjustable straps made from leather or plastic (nylon) as shown in Figure 2.

Other points of interest include:

6) Current cost of a sleeve length glove is approximately $175 per glove.
7) Maintenance – the gloves are typically hosed down with pressurised hot water (50+ degrees) at the completion of a shift as the open weave mesh typically becomes clogged with small meat particles (see Figures 2 and 3).
8) The gloves are repairable in the event of damage. Damaged gloves are sent back to the manufacturer.
9) The weight of a sleeve length glove is approximately 750-1000grams however this is dependent on the gauge of the mesh and glove size and length.

Figure 3 - Cleaning station – removal of ‘clogged’ particles (Source: Taken by Tim Phillips during project orientation 7.10.11)

## 4.2 Proposed design – Product overview

### 4.2.1 General description of product design process

The concept for the new glove design was developed after an initial site visit to the processing plant on 7.10.11. The site visit consisted of a plant tour where a variety of operational procedures and user rituals were observed and informal discussions with operators contributed to the understanding by the Kennovations design representative. This observational session was coupled with an open forum discussion with a panel consisting of band saw operators and management representatives. The panel presented their opinions on the glove in order to stimulate discussion and provide insight into a range of potential design considerations. Following the site visit several telephone interviews with management and operators in plants from other states assisted in building an understanding of the user profiles. The profiles and associated background research were subsequently used in brainstorming sessions at Kennovations where broad conceptual solutions were proposed and the identification of potential opportunities and limitations were discussed. The purpose of these initial sessions was to identify one or more ideas of merit, and subsequently develop a design to a point where the concept could be clearly communicated to the industry. The concept proposed in this report is not intended to represent a resolved solution, rather a conceptual idea that requires further development in order to verify its potential. The general design process utilised by Kennovations is featured in Figure 4. The project activities completed in order to submit this report can be considered to have been captured within Stage 1 only. Subject to review the concept may be taken further (Stage 2 onwards).

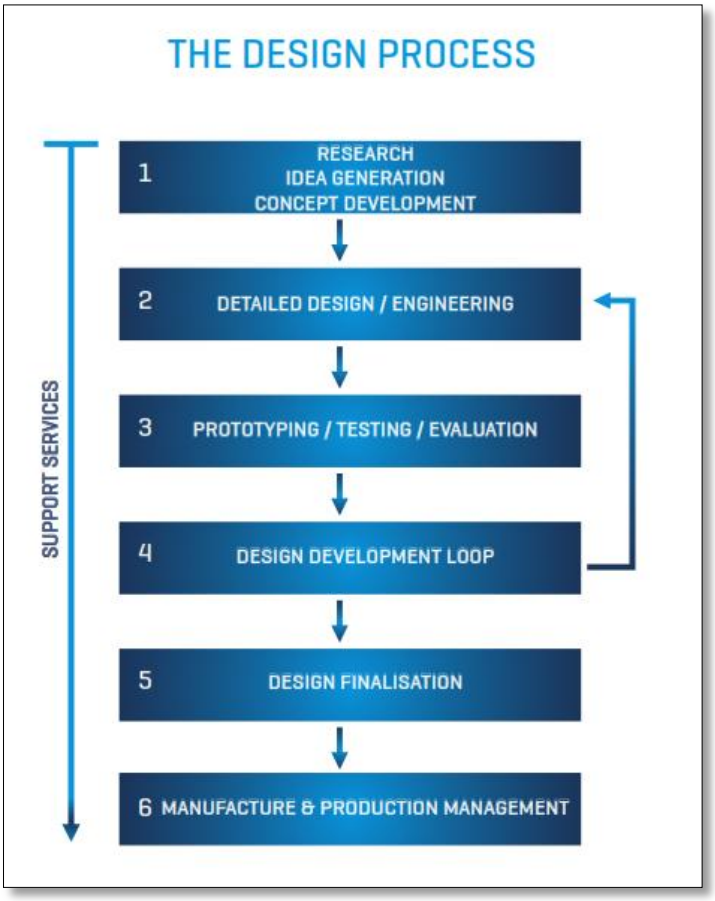


Figure 4 - The Design Process

The conceptual design phase aim was to provide a product with the following desirable features:

- reduced general complexity by reducing the number of material variations and component numbers.
- reduced need for the operator to consciously maintain a low risk condition – this target was based on observations that in the current situation the wearer must firstly remember to apply the 'spider' to improve the performance of the glove, and secondly monitor its effectiveness every day. The fact that the 'spider' needs replacement might suggest that an operator is progressively exposed to increased risk across the period the device degrades.
- a 'one piece' product to simplify hygiene, maintenance, and sourcing management
- a more comfortable, formfitting, lightweight, easily adjusted product
- a design that will not reduce current productivity levels (relative to the existing chain mail glove)
- provide the potential to customise the glove to suit the specific band saw operation or industry needs
- provide a glove concept that could be developed into a range of products with broad commercial potential.

### 4.2.2 Material selections and functions

The success of the glove concepts presented will be largely dependent on the capacity of the two core material selections. Primarily the glove needs to be able to maintain productivity by providing flexibility through the silicon or polyurethane membrane, combined with increased safety provided by the cut resistance of the metallic polymer scales.

### 4.2.3 Silicon / Polyurethane membrane

The main structural component of the glove is conceptualised to be silicon or polyurethane. Both materials would provide similar benefits and will be referred to conjointly as the 'membrane'. Further development would be required in order to select the most appropriate material or combination thereof. The membranes main purpose is to provide flexibility to the operator however several other benefits may result from the material selection:

- by utilising a flexible material the operator has a greater potential to retain dexterity and tactile control over the product being handled
- the membrane can be made relatively thin (1-2mm material) and close fitting. The ability to minimise the profile of the glove will in turn reduce the incidence of accidental contact with the blade.
- Non-porous integral hinging between the scales reduces the potential for meat particles to become trapped in the glove and significantly reduces the time required to clean/sterilise the glove
- the membrane is non-porous which will improve waterproofness and possibly eliminate the need for the yellow rubber under glove all together
- the material could be lined internally with a more comfortable/warm fabric if required, or externally with existing cut resistant meshes for protection during boning activities

- insulating properties may assist in providing warmth to the operator which would be beneficial for those who work in refrigerated environments. Thinner material may be useful for non-refrigerated environments
- moulded integration of features such as straps for adjustability ensuring a tight fit on the sleeve without the needs for extra components.
- moulding can produce a broad range of colours for identification of different products in the range or corporate branding.
- in the event that the membrane is damaged and contaminates food it is of a suitable food grade

Some potential limitations of the material may be:

- the overall durability relative to chain mail glove
- possible inability to repair the membrane glove in the event of damage.

More consideration has to be been given to how the glove will perform long term and how it can be adequately maintained.

### 4.2.4 Metallic polymer scales

**Material choice** - the scales (or plates) featured intermittently along the length of the glove provide resistance to the cutting action of the blade. There are a broad range of materials the scales could be manufactured from and an even greater number of material combinations. This opportunity is provided by a method for manufacture called powder metallurgy. This process generally fuses powdered metals, however, due to rapid advancement of modern technology, these days materials are seldom made of only metals and metallic alloys. Rather it often incorporates ceramics, ceramic fibers, and intermetallic compounds[7]. This process will permit the manufacturing of customised metallic and copolymer compounds and can readily produce the required organic shapes. The sintering process and subsequent surface hardening treatments available will enable a hard and cut resistant scale to be developed. Ceramics and other non-metallic materials were reviewed for suitability however in the event of glove damage, the metallic scales or fragments would still be detectable by existing x-ray technology employed by large plants in order to pick up foreign materials.

**Scale positioning** - the scales are positioned only on the rigid (or non-hinging) elements of the forearm and hand. This intermittent positioning does not restrict flexibility. The knuckles and wrist are free to provide full dexterity. Preliminary research suggested that the common operator fear of being ‘dragged in’ was a result of blade teeth gripping the weave of a fabric glove or the chain mail rings. In order to address this scenario the individual solid plates attempt to minimise the number of potential catching points the blade can grip. In the event of blade contact with the edge of the scale it is intended that the scale itself is separated from the balance of the glove – the silicon acts as a release point between the skin/arm and the scale. This design does not completely eliminate the chance of the blade catching on the scales, but it will significantly reduce the chance of this occurring.

**Design limitations** - it is accepted that by not protecting the entirety of the hand some areas (between the scales) are still subject to blade exposure. It is proposed that this situation

[7] http://www.themetalcasting.com/powder-metallurgy.html

presents a significantly better scenario relative to not wearing any glove at all. The design reinforces that a compromise is inevitable in order to achieve a balance of safety and productivity. Scales that overlap and protect the joints/knuckles more were considered, however resulted in a significantly bulkier design and increased the likelihood of accidental collision with the blade.

### 4.2.5 Design overviews

In order to protect the intellectual property developed during this project the images of the design(s) have been omitted. For further information on this project please contact Meat & Livestock Australia Limited.

# 5 Conclusions and recommendations

## 5.1 Further development

In order to progress the glove design/s several stages of development are required. The concepts presented within are preliminary only and a range of research and development activities must be undertaken to verify the design methodologies and the material capabilities to deliver the intended overall functionality. It is important to note that only a preliminary review of OH&S documents and informal interviews was used to develop the current concepts. A detailed review of the following is required:

- OH&S records in order to categorise injury types, frequencies, severities
- Band saw brands and types
- Cut types and variations
- Proposed material properties and manufacturing methods
- Ergonomic and anthropometric data of operators (hand sizes, range of movements)
- Relevant Australian and international standards
- Any additional testing reports which focus on chain mail glove risks

The resulting information can then influence a detailed design & engineering phase which will include the development of:

- Existing computer models and design documentation
- Form studies used to verify aesthetic and ergonomic features
- Prototypes and testing programs for individual components and assemblies
- Manufacturing process reviews
- Product integration strategies
- Commercial strategies (Funding / Intellectual Property / Partnerships with manufacturers etc.)

The amount of time and money required to complete the steps above is subject to many factors including the amount of useful information and its' availability, project budgets, timelines and objectives. Other factors can affect the program and as such a review of this report and a number of follow up meetings are required in order to develop a suitable scope of works.

# 6 Supplementary concept

## 6.1 The Laser 'Danger zone' system

This concept is presented as a possible development of existing technologies, as an alternative or complimentary technology to the protective glove. This concept would require a similar developmental path to the glove as outlined in Section 5 and should be considered is provided to stimulate further discussion on the appropriateness of existing technologies and the possibility for ongoing improvements.

It is understood that the processing plant visited during orientation is not alone in the industry in using laser lines on some of its band saws. It was noted through informal discussion during the site tour and subsequent telephone interviews (with other leading processors) that these systems have been implemented in order to improve safety, but have been met with mixed review. A visual representation of the current laser system in use at the visited plant can be seen in Figure 11.

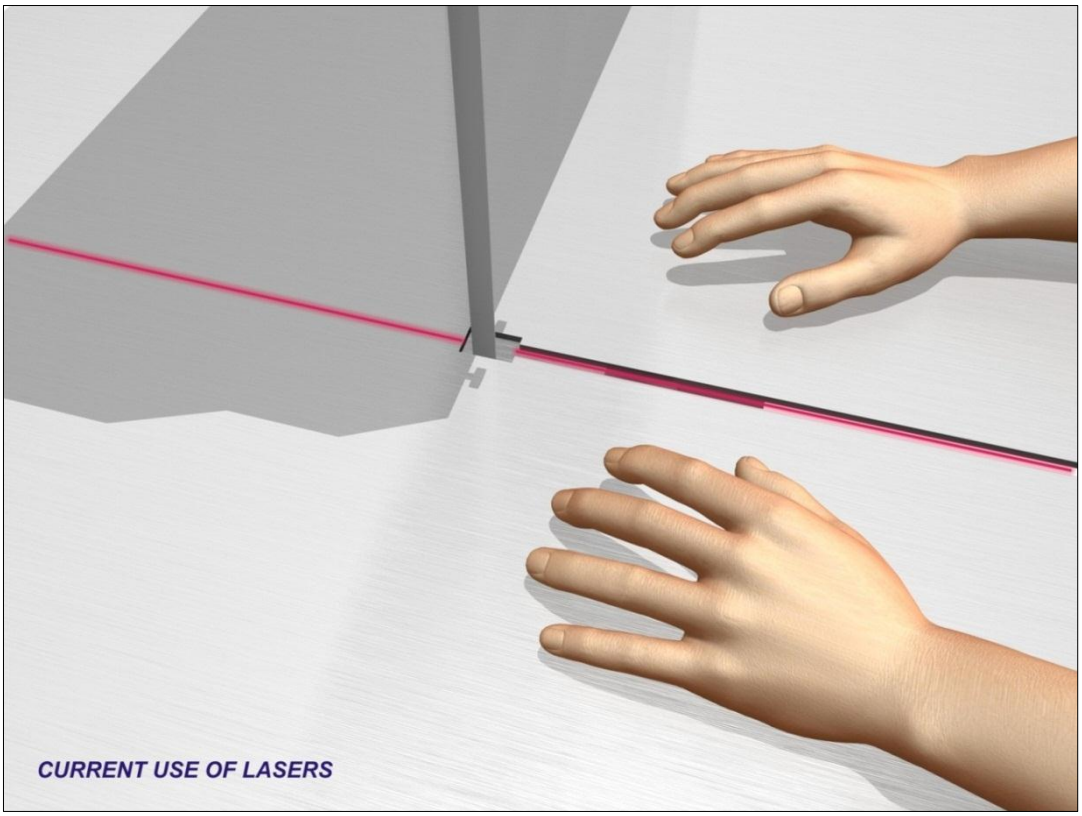


Figure 11 – Visual representation of the current laser system in use at Dinmore.

Laser line kits as pictured in Figure 12 are currently available for retro-fitting to band saws and retail for a price of around $950[8].

[8] http://www.ferret.com.au/c/Bandsaw-Supplies/Laser-Line-Generators-from-Bandsaw-Supplies-p22469

Figure 12 – Band saw Laser line generator

Source: http://www.ferret.com.au/c/Bandsaw-Supplies/Laser-Line-Generators-from-Bandsaw-Supplies-p22469

The device is affixed to the upper portion of the saw as can been seen in the visual representation in Figure 13.

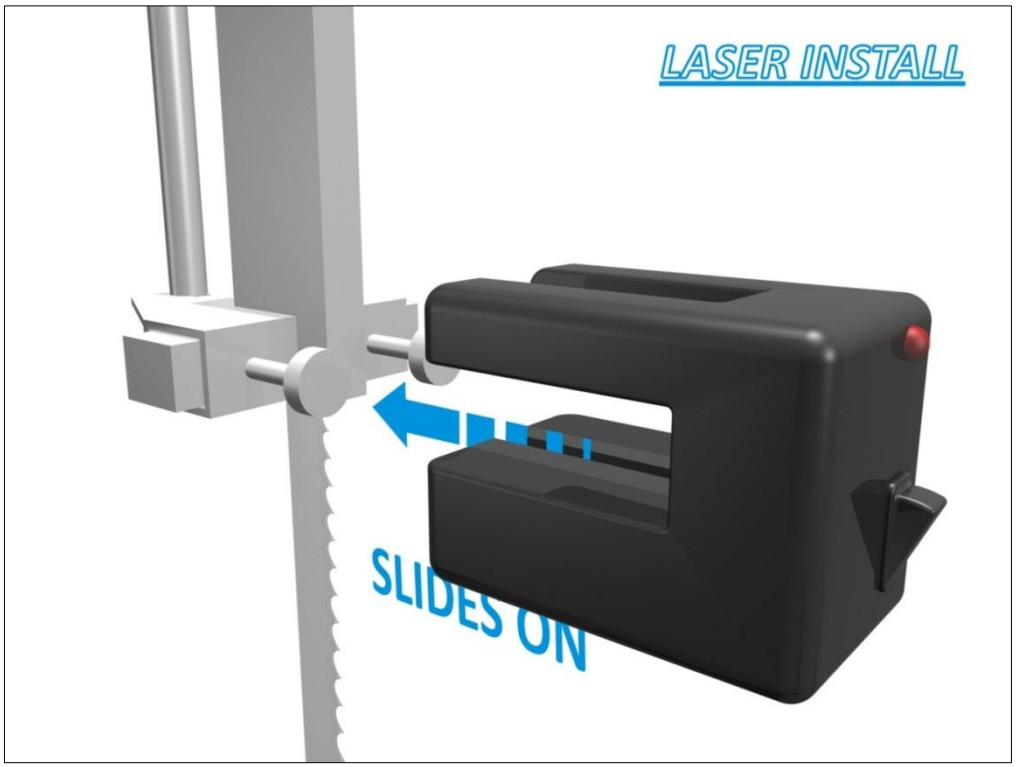


Figure 13 - Visual representation of the attachment concept for the current and developed concept

It is proposed that these laser systems were not developed specifically to improve operator safety but rather provide greater accuracy on cut positioning. It is also proposed that a laser system that focuses on safety rather than accuracy can be developed. This system could be integrated into new band saw designs and also developed as a retro-fit product to cater for the large number of existing machines, for use in production scenarios, or in training activities for new operators.

As no significant technological advances would be required to achieve the proposed concepts it would be expected that similar pricing could be achieved dependant on manufacturing volumes and design detail. It is understood through informal discussions with industry management that for a device that improved safety or training, similar pricing would not be a prohibitive factor in the products implementation.

It is observed that the line in its current form only provides an indication of the blades location in a single plane i.e. providing the operator an indication of blade location left to right, but no indication of proximity to the blade front to back (during standard operation). The opposite would be true if the band saw is side operated as can be seen in Figure 14. A laser design that provided a better indication of the blade proximity from all directions may result in fewer injuries due to blade contact and provide greater protection across the range of band saw blade orientations.

Figure 14 - Side operation of a band saw
(Source: Taken by Tim Phillips during project orientation 7.10.11)
Note: Green laser line superimposed

Three (3) possible design concepts (Laser Pattern A-C) were presented in the original report. In order to protect the intellectual property developed during this project the images of the design(s) have been omitted. For further information on this project please contact Meat & Livestock Australia Limited.

The designs provided in the original report feature possible laser light profiles which may improve user awareness of the 'danger zone' for standard band saw orientation and cut direction. Other design variations may provide increased visual awareness of this area depending on the number of variables (cut type, saw type, cut orientation etc.) A better understanding of these variables is required in order to develop more appropriate solutions.

Notes:

- It could also be considered that an increased awareness of the 'danger zone' may also improve operator efficiency if cautiousness in the proximity of the zone currently results in a change in operator behaviour.
- Informal discussion with band saw operators indicate that the laser lines can be somewhat distracting as the operator's attention is actually on the line rather than the blade itself. A better understanding of where the operator's visual attention is focused throughout the duration of a cut cycle is important for future developments. It is expected that there are periods when the operator is observing the product in isolation from the blade, the blade in isolation from the product, and a scenario where peripheral vision is utilised to observe both at once.
- The laser line utilised in the visited processing plant was also observed to vibrate and shake with the moments of the machine and machine platform. This vibration could be seen as distracting and possibly lead to inaccuracies in cutting and increased cautiousness from operators. These items would also need review during the development of the product. Improvements in machine stability, cutting platform stability, and the rigidity of the laser delivering system may improve operator safety.

# 7 Appendices

## 7.1 Guidelines on the selection and use of cut resistant gloves in the meat industry – Safer Industries

## Contents


| | | |
|---|---|---|
| Preface | | 1 |
| Introduction | | 3 |
| Laceration injury profile | | 5 |
| AQIS and hygiene requirements | | 6 |
| Task requirements | - knife hand | 7 |
| | - non knife hand | 7 |
| Glove selection | | 8 |
| Benefits of cut resistant gloves | | 9 |
| Problems with current designs | | 10 |
| Future challenges | | 11 |
| Sources of information | | 12 |
| Acknowledgments | | |


Meat Industry

SAFER Industries

## Preface

These guidelines have been developed by the SA Meat Industry OHS Committee to provide practical guidance on the use of cut resistant gloves in the South Australian meat processing industry.

Guidelines are advisory documents to help employers comply with their 'Duty of Care' under the SA Occupational Health, Safety and Welfare Act, 1986, and the OHSW Regulations, 1995. These guidelines provide advice to those with responsibilities in the meat industry who need to ensure they meet their legal obligations to provide safe systems of work and safe plant and equipment.

The guidelines should be considered an important source of information and advice, and a useful starting point for consultation between employers, employees and their representatives, and glove suppliers. As part of the risk assessment process, the guidelines will be useful in selecting and evaluating which gloves are appropriate for each workplace and situation.


2
Cut resistant gloves in the meat industry
Guidelines on the selection and use of

# Introduction

The incidence of serious laceration injuries to the hand and arm, as well as amputations, are major occupational health and safety concerns for the meat industry in South Australia. The livestock processing class of the meat industry is the worst performing industry group in South Australia in terms of workers compensation costs paid per payroll.

This guideline has been developed as a result of a 'SAfer Industries' project, funded by the WorkCover Corporation Grants Scheme. The project has involved:

- a review of literature relating to the use of cut resistant gloves by meat workers
- a survey of all meatworks in South Australia to determine the current use, and feedback, on gloves worn by meatworkers
- discussions with AQIS and meat hygiene technical experts to ensure microbiological standards for meat are maintained when cut resistant gloves are worn
- a six month field trial of three brands of cut resistant gloves involving meat workers from five meat works in South Australia
- surveys administered to participating meat workers trialling the gloves after two weeks, three months and six months of use
- a review of workplace diaries detailing performance issues, wear and tear, as well as cleaning and comfort issues.

These guidelines have been developed to assist meat workers and their managers select and use the appropriate cut resistant gloves to suit the needs of the industry.

The postal survey relating to the wearing of cut resistant gloves was sent in May 1999 to every meat works in South Australia.

It was evident from the results that currently:

- over 50% of meatworkers wear no form of cut resistant gloves at all
- the chain mesh glove is the most commonly used form of hand protection. The survey revealed that around 40% of meatworkers wear the chain mesh glove on their non knife hand.
- the remaining 10% who wear gloves, use a cut resistant fibre glove on their non knife hand
- less than 5% of meatworkers wear a cut resistant fibre glove on their knife hand

It was evident from the results that currently:
Wearing of disposable rubber gloves was found in most meat works where constantly washing of the knife in 82 degrees Celsius water was required. It was also found that a number of people dipped their glove into the 82 degrees Celsius water as well, thereby aiming to avoid cross contamination as required y AS 4461/1997, "Australian Standard for hygienic production of meat for human consumption (2nd ed)". However this is not a practice that is recommended as the hot water can easily burn the hand, particularly if there is a small hole in the rubber glove.

- the chain mesh glove, whilst seen to add protection from knife cuts was generally disliked by meatworkers due to:-
  - poor comfort and fit to the range of male / female hand sizes
  - poorly fitting finger tips resulting in lack of grip sensitivity with fingers
  - mesh gets cold, and chills the hand in 10°C temperature controlled work rooms
  - cleaning of hair, meat and bone fragments difficult from mesh
  - weight of glove causes hand / arm fatigue, particularly when worn with full mesh forearm guard
- resistance to wearing cut resistant fibre gloves is greater amongst experienced meatworkers who have previously not worn any glove
- initial concern towards wearing a glove on knife hand was due to a perceived reduction of grip strength and dexterity on knife handle.

## Laceration injury profile

The WorkCover Corporation database (1996/99) indicates that nearly 30% of claims in the meat industry were hand and wrist lacerations. (figure 1)

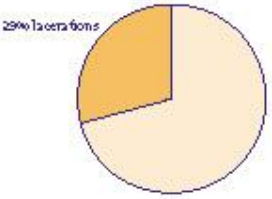


figure 1: SA WorkCover Corporation Claims in the meat industry (1996-1999)

In terms of agency of incident, over the same period of time, knives accounted for nearly 30% of all WorkCover claims in the meat industry. (figure 2)

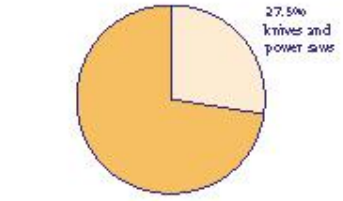


figure 2: Agency of injuries (1996-1999)

These knife lacerations account for around 25% of all workers compensation costs to the industry, with sprains and strains accounting for over 50% of costs.

These lacerations included:

- cuts to the non knife hand and forearm
- 'run through' lacerations i.e. knife hand slides over edge of knife grip across razor sharp knife blade

Amputations of fingers / joints were also reported in the database.

Case study data indicated days lost from knife cuts are extended when infection is identified.

NB. No glove should be worn when operating a bandsaw, as gloves can get trapped in the teeth of the saw and drag the hand in. Bandsaws should be guarded.

## AQIS and food hygiene

The Quality Assurance processes in the meat industry require strict meat handling procedures to control microbiological levels and ensure meat quality. The 'Australian Standard for hygienic production of meat for human consumption (2nd edition)' (AS4461-1997) sets standards relating to meat processing procedures for export and domestic meat works.

Previous attempts to introduce cut resistant fibre gloves failed due to problems in cleaning the gloves, and unacceptable microbiological levels. Research conducted by the CSIRO and Australian Meat Technologies Pty Ltd has enabled AQIS to approve two fibres as acceptable for use in temperature controlled areas of meatworks. These fibres are:

- Kevlar
- Spectra.

It is still necessary for strict cleaning controls to be followed, and microbiological checks to be undertaken.

The product at export sites has not been found to be contaminated by fibres from cut resistant gloves.

Disposable water resistant gloves are still required to be worn over the cut resistant fibre gloves in slaughtering and dressing areas where cross contamination between carcasses is possible.

In those situations, where a chain mesh glove is used, a rubber glove is worn underneath.

Cut resistant fibre gloves can be worn without water resistant gloves over them in temperature controlled boning rooms.

Details relating to standards for glove use can be found in AS4461-1997 'Australian Standard for hygienic production of meat for human consumption (2nd edition)'.

## Task Requirements

An ergonomic assessment of gloves is based on the profile of people using the gloves, and the tasks they perform. In the meat industry, knives are used in all the various stages of processing. Operators who use the knives present with the full range of hand sizes of the Australian adult population.

**Knife hand**

In most instances, meat workers use their dominant hand with the knife. However, there are a number of cuts where they are required to change the knife to their non dominant hand. This particularly occurs in the slaughtering processes. These cuts present problems due to the wearing of a thick cut resistant fibre or chain mesh glove on the non dominant hand, limiting the ability to grip the knife.

The force exerted via the knife in a cut is determined by:

- temperature of the meat / fat
- posture of the wrist / arm
- sharpness of the knife blade
- length and duration of cuts (Meat Research Corporation, 1990).

The grip onto the knife handle can directly reduce the ability to sustain consistent force exertion. Hence, the wearing of a glove on the knife hand may reduce the ability to grip the knife securely.

The incidence of over use injuries to the hand / wrist / arm in the knife hand has been of ongoing concern. The potential for the glove to increase or decrease the probability of such injuries is also an area of concern and needs further research.

**Non knife hand**

The non knife hand is more commonly in contact with the meat, as the knife performs the particular cuts. In slaughtering, the fingers can grip the meat being cut or hold a hook or forceps which help tension the meat during the cutting process. The grips adopted range from fine finger control required to separate tissue to full hand grips as required in holding segments of meat.

The majority of laceration and stab injuries occur to the non knife hand and forearm. Hence, the chain mesh glove has traditionally been worn to protect this arm. This is due to the close proximity of the knife blade to the non knife hand as the cuts are being performed.

Due to the AS 4461-1997 requirements, in non-refrigerated areas a water resistant glove must be worn under the chain mesh glove to enable frequent immersion of the knife into water. A water resistant glove can also be worn under a chain mesh glove in temperature controlled rooms to help keep the hand dry and warm from the cold conductive chain mesh.

## Glove selection

An international literature review was conducted to identify commercially available cut resistant gloves that contained either of the approved fibres i.e. Kevlar or Spectra.

Three brands of gloves were evaluated in the field trials. These were:

- Ansell
- Polar Bear
- Whizzard Handguard / Liteguard

Each brand supplied a range of hand sizes in a thick knit for use on the non knife hand and a thin knit for the knife hand.

The gloves are available from the main suppliers of protective clothing to the Australian meat industry. The prices for each glove range from $12 to $25 depending on brand and style. Additional costs are required for the disposable rubber gloves.

By comparison, the cost for a mesh glove is between $120 - $150.

It was found that each meat worker requires up to three cut resistant fibre gloves per hand.

These are for:

- glove in use
- dirty glove being washed
- clean glove drying.

It is not in the scope of these guidelines to be prescriptive in the selection of particular brands of gloves due to the limited number of trials and duration of testing.

## Benefits of cut resistant gloves

Wearing a thin cut resistant glove on the knife hand and a thick cut resistant or mesh glove on the non knife hand can reduce lacerations by up to 80%.[1]

The major benefits found from wearing cut resistant fibre gloves include:

1. The gloves offer increased protection from knife cuts when worn on both the knife hand and non knife hand, compared with wearing no gloves at all.
2. Wearing a thin cut resistant glove on the knife hand will particularly reduce 'run through' lacerations on the knife hand (pictured at right).
3. These gloves keep the hands warm in cold work environments and when handling cold/wet meat.
4. The gloves offer a better fit to the hands and are more comfortable than the chain mesh gloves.
5. As pictured below rubber gloves can be worn under the mesh glove, or over the thin cut resistant gloves.

6. Changing of knife between hands is relatively easy with cut resistant gloves but impossible with a chain mesh glove.
7. Cut resistant gloves allow improved dexterity of finger tips as opposed to using a chain mesh glove.
8. Reduced weight of glove, compared to chain mesh, reduces tiredness of hand and arm.
9. Once accustomed to the glove, the grip of knife handle not diminished by wearing of thin cut resistant glove.
10. Cleaning of gloves to comply with AS 4461-1997 maintained by following manufacturers instructions.
11. Purchase cost of individual glove cheaper than chain mesh glove.

1 Source: Data from five participating SA meatworks over nine month period and data from two major abattoirs in Queensland and New South Wales.

## Problems with current designs

The following cautions are offered to users of these gloves, and have been directed to the glove manufacturers for future design improvements.

1. Operators who trialled the gloves found that the range of sizes did not match the anthropometric measurements of their hand sizes.
2. The thickness of the larger glove is not compatible for wearing a rubber glove over the cut resistant glove.
3. The gloves are not stab resistant.
4. The knit of the gloves is easily damaged by sharp bones e.g. kangaroo.
5. The wrist band of the gloves stretch from washing, and become loose after 3-5 months of regular laundering.
6. The seam of the fabric at the finger tips reduces tactile control when handling meat tissue.
7. It is not as easy to quickly remove cut resistant glove compared to chain mesh glove if a small cut in rubber glove allows 82°C water to make contact with fingers.
8. Need to purchase, name and process, multiple gloves per worker due to washing and drying requirements.
9. Matter can gather in fingertips during laundering even when turned inside out.
10. Only light coloured gloves are acceptable under AS 4461-1997 'Australian Standard for hygienic production of meat for human consumption (2nd edition)'.

## Future challenges

The introduction of cut resistant gloves into South Australian meat works should be promoted particularly where no form of mesh glove or other protective gloves are worn. In particular, the thin cut resistant glove should be worn on the knife hand to significantly reduce 'run through' lacerations.

Further research will be required to assess the long term effects of wearing gloves on occupational overuse injuries for both the knife and non knife hands. The warmth retained in the hand by the cut resistant glove should assist in injury prevention. However, any tendency to increase grip strength onto the knife handle may increase injury risks.

The need to wear the cut resistant glove in conjunction with an impervious rubber glove in many knife tasks requires the manufacturers to design gloves to enable these to fit comfortably together, or to design an impervious cut resistant fibre glove. Manufacturers also need to validate their glove sizes to reflect current research on anthropometry of hand sizes. Ergonomic issues relating to finger dexterity and swapping the knife between hands require future consideration. Performance issues relating to cleaning and deterioration of the gloves from wear needs attention in future design enhancements.

Evaluation of other initiatives to reduce lacerations from knives is required. This includes the use of forceps, tweezers and hooks to grip meat tissue, rather than using fingers in trim areas. It also includes alternative knife handle designs to reduce the chance of 'run through' injuries.

While there are knives with guards designed to reduce run throughs, they need further evaluation. Further research would be helpful to evaluate recent knife releases from Germany. Other knives also offer features that may reduce injuries.

**Traditional boning knife**

**Alternative knife handle design – boning knife**

**Alternative knife handle design – skinning knife**

## Sources of information

Additional sources of information can be obtained from:

**The SA Meat Industry OHS Website**
www.workcover.com/safer/meat.html

**South Australian Meat Industry OHS Committee**
Paul Sandercock, Chairperson
Executive Director, SA National Meat Association
Floor 1, 100 Greenhill Road
Unley, SA 5061
Telephone: (08) 8272 2400
Fax: (08) 8272 2433
Email: nmasa@tne.net.au

**Meat & Livestock Australia**
Margie Mahon, OHS Project Leader
Locked Bag 991
North Sydney, NSW 2059
Telephone: (02) 9463 9166
Fax: (02) 9463 9182
Email: Margie_Mahon@bigpond.com

**WorkCover Corporation**
Janice Quarrie, Meat Industry OHS Consultant
SAfer Industries Project
Workplace Safety Management Division
100 Waymouth Street
Adelaide, SA 5000
Telephone: (08) 8233 2947
Toll free: 1800 188 000
Fax: (08) 8233 2223
Email: jquarrie@workcover.com

**Meat industry protective clothing suppliers including:-**
Ansell
Hepworths
Protector Safety

## 7.2 WORK COVER NSW - Catalogue No. WC01356: Fact Sheet MANAGING RISKS ASSOCIATED WITH BANDSAWS IN THE RETAIL, MEAT, SEAFOOD AND POULTRY INDUSTRIES

WORKCOVER
NEW SOUTH WALES

# FACT SHEET

# MANAGING RISKS

## ASSOCIATED WITH BANDSAWS IN THE RETAIL, MEAT, SEAFOOD AND POULTRY INDUSTRIES

**WHAT IS THE PROBLEM?**

This fact sheet is aimed at assisting employers and employees manage the risks associated with bandsaws used in the Retail Meat Industry. The steps and information provided here should be read in conjunction with the requirements set out in the Occupational Health Safety (OHS) Act 2000 and the Occupational Health and Safety (OHS) Regulation 2001.

Bandsaws can pose a serious risk to health and safety at the workplace. In NSW each year, there are numerous workers' compensation claims for major injuries involving powered saws in the retail, meat, fish and poultry Industries, costing upwards of $300,000 per claim. Anyone at work, particularly employers, can reduce the risks associated with bandsaws through good workplace health and safety management. Effective solutions are often simple and lead to other benefits.

**THE BENEFITS INCLUDE:**

- direct benefits - reduced insurance premiums, reduced litigation costs, reduced sick pay costs, improved production and productivity rates, lower accident costs and production delays, reduced product spoilage
- indirect benefits - reduced absenteeism, reduced staff turnover, improved corporate image, improved chances of winning contracts, improved job satisfaction and morale.

**WHAT DOES THE LAW SAY?**

The OHS Act 2000 requires employers to ensure the health and safety of all employees at the workplace and to provide and maintain a safe place of work.

Section 8 of OHS Act places a duty of care on all employers to provide for the health, safety and

welfare at work of all their employees. This duty includes:

- ensuring that the workplace is safe and without risks to health
- ensuring that any plant provided for use by employees at work is safe and without risks to health when properly used.
- ensuring that the systems of work and the working environment of the employees are safe and without risk to health
- the provision of such information, instruction, training and supervision as may be necessary to ensure the employees' health and safety at work.

Chapter 2 Clauses 9–12 of the OHS Regulation places a responsibility on all employers to adopt a risk management approach. In addition, some particular risk control measures are required. The control measure include:

- assessing the risks
- taking actions to eliminate or control the risks
- keeping risks under review and the measures taken to address them.

Chapter 4 Clauses 45–81 of the OHS Regulation, places responsibility to evaluate and if necessary establish particular risk control measures in relation to working space, lighting, heat and cold, noise, atmosphere, working at heights, fire and explosion, electricity, confined spaces and manual handling.

Chapter 5 Clauses 82–142 of the OHS Regulation relates to plant (including bandsaws) and further adopts a risk management approach. Clauses 134–144 relate to working with plant and include its installation, commissioning, use, maintenance, dismantling, storage and disposal, as well as safeguarding of the plant.

**WHAT ARE THE RISKS ASSOCIATED WITH BANDSAWS IN MY BUSINESS?**

NSW OHS legislation requires all employers to identify hazards in their workplace. This includes any bandsaws in the workplace, and any hazards they may present. Employers are also required to take action to eliminate or minimise these identified risks. Some simple actions can be taken to determine the likelihood and severity of an injury or incident occurring in relation to bandsaws.

- Have a look at previous injuries that have occurred in your workplace and identify those that have been attributed to bandsaws. You can also find out from your industry association what

types of incidents are common with bandsaws.

- Consult with your employees about their concerns and experiences.
- Record 'near miss' incidents to help flag problems before they cause an injury.
- List possible hazards (eg coming into contact with saw blade).
- Have in your possession, information about bandsaws used at your workplace, such as relevant Australian Standards, and operation and maintenance manuals provided by the manufacturer or designer.

**HOW DO WE DETERMINE THE RISKS ASSOCIATED WITH BANDSAWS?**

There are 4 simple steps to identifying risks associated with bandsaws. The Bandsaw checklist available through WorkCover will also help identify unsafe bandsaw practices.

| | |
|---|---|
| Step 1 | Identify all bandsaws used at the workplace. |
| Step 2 | Consider who might be injured and how. (Who comes into the workplace and are they at risk?). |
| Step 3 | Consider the risks. Are there existing measures already in place? Are they enough? |
| Step 4 | Take steps/measures to eliminate or reduce the risk. |

**WHAT CAN BE DONE TO MANAGE THE RISKS ASSOCIATED WITH BANDSAWS IN THE WORKPLACE?**

Ensure that all bandsaws are maintained and safe to use.

- List all the bandsaws in your workplace.
- Identify what has the potential to cause harm.
- Identify what control measures are already in place eg guards.
- Conduct a risk assessment in consultation with the employees.
- Determine control measures such as redesign to eliminate the hazard and document controls such as safe working procedures.
- Implement control measures and provide regular review.
- Complete regular inspection and testing of the bandsaw.
- Ensure all persons who are to operate and use bandsaws at the place of work are provided with appropriate information, instruction and training in bandsaw operation and use.
- Ensure that guarding of dangerous parts is in place.

- Ensure regular maintenance is completed in accordance with the manufacturers specifications and/or other relevant standards.
- Ensure all maintenance and cleaning is undertaken with the bandsaw effectively isolated and prevented from inadvertently being turned on.

**WHAT ABOUT BANDSAW MAINTENANCE?**

Appropriate maintenance of bandsaws is vital to ensure their continued safe operation. Plant must be maintained in accordance with manufacturers specifications, safe operating procedures and in some instances specific regimes identified within Australian Standards and/or approved industry Codes of Practice.

**WHERE CAN I GET FURTHER INFORMATION?**

www.workcover.nsw.gov.au
WorkCover Assistance Service 13 10 50

INDUSTRY CONTACTS: Australian Meat Industry Council (AMIC) 25 - 27 Albany St, Crows Nest, NSW 2065 Ph.: (02) 9086 2200 Web: www.amic.org.au

Australasian Meat Industry Employees Union (AMIEU) NSW Branch: Unit 3190 George Street Parramatta NSW 2150 Ph: (02) 9893 9011 Toll free: 1800 451 535
www.users.bigpond.com/amieu/index.html

Newcastle & Northern Branch:
PO Box 2263
Dangar NSW 2309
Ph: (02) 4929 5496



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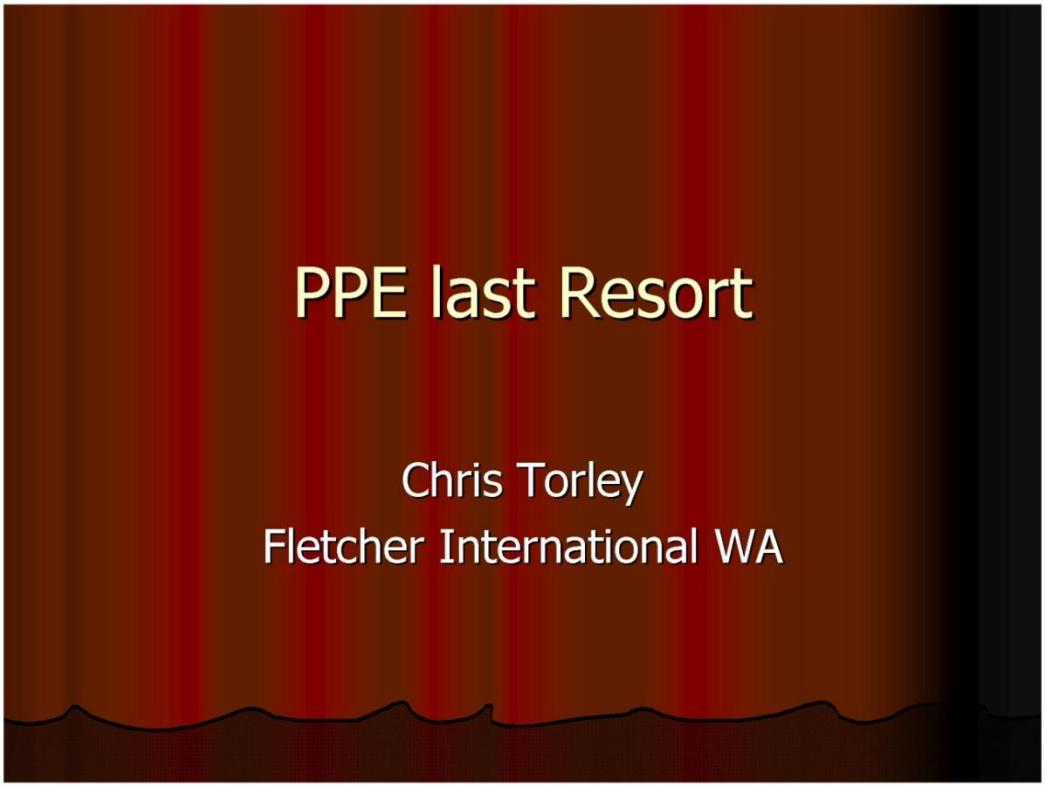
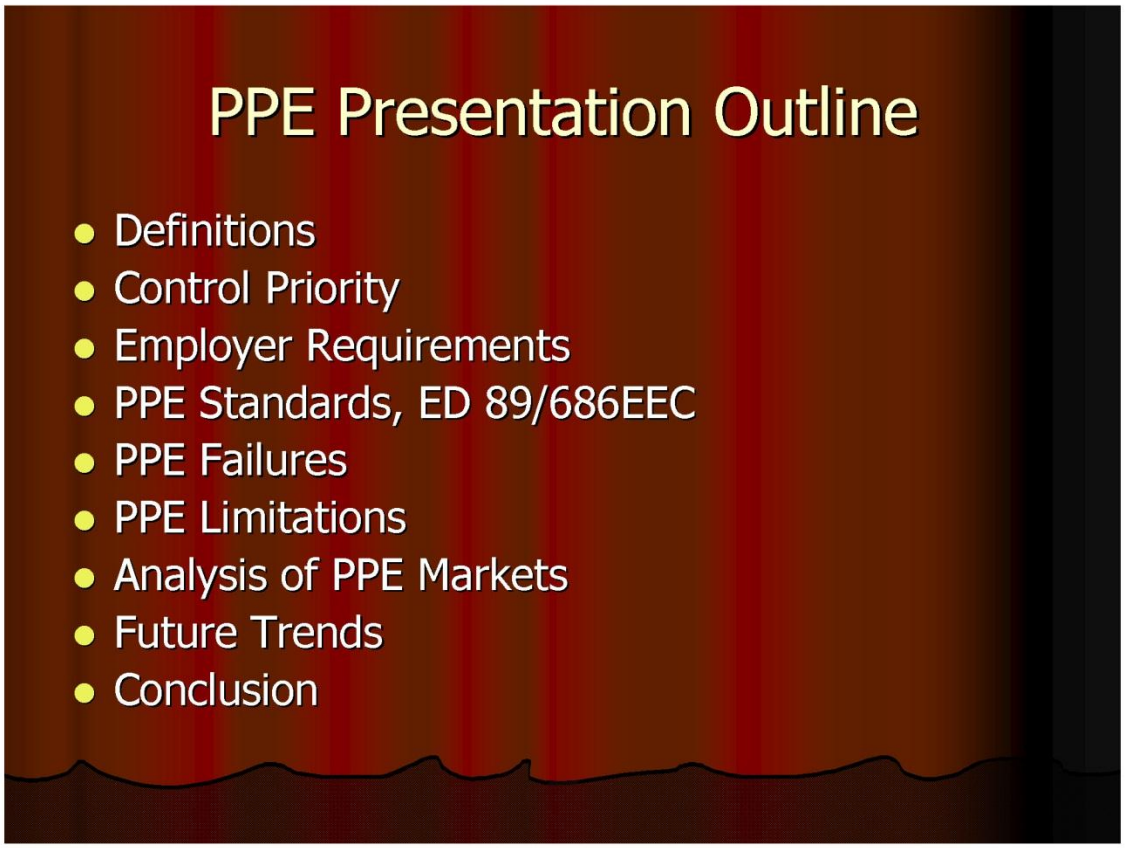
**WorkCover NSW** 92-100 Donnison Street Gosford NSW 2250
Locked Bag 2906 Lisarow NSW 2252 WorkCover Assistance Service **13 10 50**
Website www.workcover.nsw.gov.au 0608

## 7.3 The Australian Meat Industry Council (AMIC) and WorkCover NSW – Bandsaw Safety Poster 3084[1]

## 7.4 PPE Last Resort – Presentation by Chris Torley, Fletcher International WA



## PPE Definitions

- PPE includes all clothing and work accessories designed to create a barrier
- PPE is all equipment intended to be worn or held by a person at work to protect him from one or more risks
- PPE covers any item for wearing or carrying by the worker with the aid of protecting them from one or more risks likely to cause injury or jeopardise health at work or accessory with the same purpose. European Directive 89/686/EEC

## PPE – Lowest in Order of Controls

- PPE not to substitute higher controls
- PPE lowest in order of control priorities
- PPE not be primary means of risk control
- PPE only when risk cannot be minimised in any other way or used in combination with other measures as a final barrier
- PPE only if other measures insufficient or while other measures are put in place

# Hierarchy of Control Measures

Eliminating the hazard is first priority if this is not possible, the risk must be minimised by measures in following order:

1. Substituting the hazard
2. Isolating the hazard
3. Engineering
4. Administrative measures
5. PPE

Most Effective Control

Least Effective

# Risk Management

Obligation holders must start at the top of the hierarchy and select control measures from the highest order, it is often necessary to use a combination of controls

Control measure(s) should aim to

- Prevent exposure
- Adequately control the risk now & over time
- Not create another hazard
- Allow workers to do job without discomfort
- Be proportionate to the nature & severity of risk

# PPE – Employer Requirements

State Legislation, Australian Standards and Codes of Practice in Australia provide guidance to Employers on –

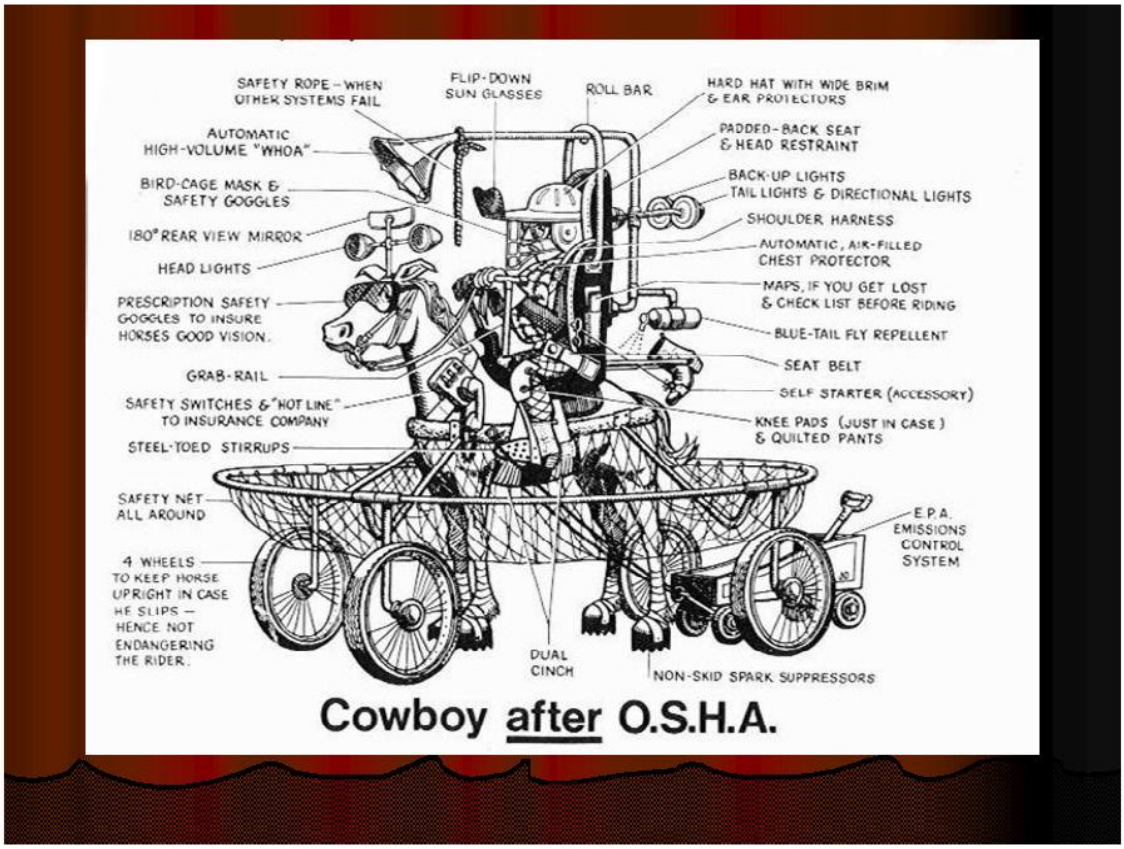
- Risk assessment
- Consultation with workers & suppliers
- Selection processes
- Training
- Provision of PPE
- Storage and maintenance

# PPE Standards

A person who designs, manufactures, imports or supplies PPE for use at a work place has a duty care to ensure that PPE is safe and does not place someone's safety or health at further risk when properly used

They must also make available technical information on PPE, design criteria, testing, performance, markings, use, care, maintenance and warnings

There are hundreds of standards for PPE, human physiology, thermal comfort, ergonomics, textiles, size designation etc.




# European Directive 89/686/EEC

## All PPE in the European Union must comply with Directive 89/686/EEC & carry the CE marking

PPE categories

1. Simple design PPE e.g. Sunglasses & garden gloves
2. Intermediate design PPE e.g. High visibility clothing
3. Complex design PPE e.g. Respiratory Protective Equip.

PPE shall:-

- Afford adequate protection & not create greater risk
- Be suitable for workplace conditions
- Allow for worker's ergonomic & health requirement
- Account for wearer's personal preferences

Where there are several risks PPE must be compatible and able to maintain its effectiveness to protect the user against risks

## SUCAM

European Committee for Standardization produced a general guidance document containing recommendations on the process and management of PPE –

S election
U se
C are
A nd
M aintenance

## Selection & Suitability

Selection of PPE should consider

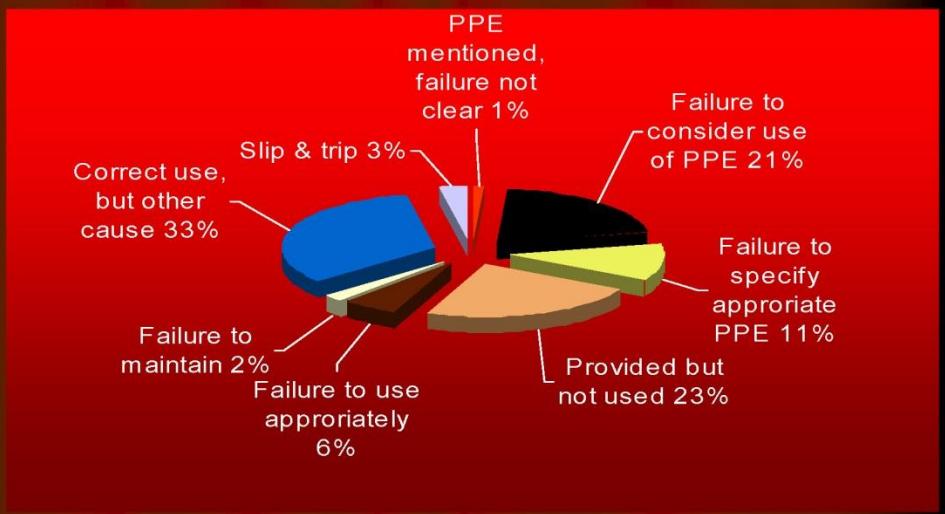
- Characteristics for PPE to be effective
- Level of protection match hazard & risk
- Intended use covered by design criteria
- PPE performance requirements needed vs product availability
- Testing reflects PPE performance in workplace environment

# Potential Failures of PPE

Research by Bomel Ltd on potential failures in use & maintenance of PPE identified a number of PPE failure types

The distribution of PPE failure types showed 60% of accidents would have been prevented if PPE that had been provided was used or if PPE use had been considered for the task

# PPE Type Failures



# Bomel Report Recommendations

The authors concluded people failings rather than equipment failings was the main contributing factor to PPE accidents

Recommendations
Identify and understand underlying causes of PPE failures:-

- Lack of supervision
- Lack of awareness/risk perception
- Lack of procedures
- Human error

## Bomel Report Recommendations

Methods to address the recommendations:-

- Using accident narratives and inspection reports to understand accident causation
- Seeking advice from Suppliers and Manufacturers
- Identifying successful use of PPE to identify how it worked and why

## The BHP Approach

BHP Billiton HSEC Report 2004

Whilst elimination of exposure risks was their main driver often there was no possible or feasible control options other than to use PPE

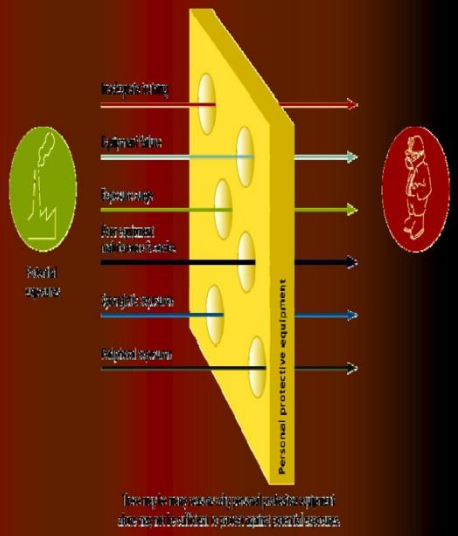
Analysis of PPE exposures revealed many reasons why PPE alone may not be sufficient to protect against potential exposures

# Potential Exposures

- Inadequate training
- Equipment failure
- Exposure surge
- Poor maintenance
- Synergistic exposures
- Peripheral exposures

More than PPE is required to provide adequate protection

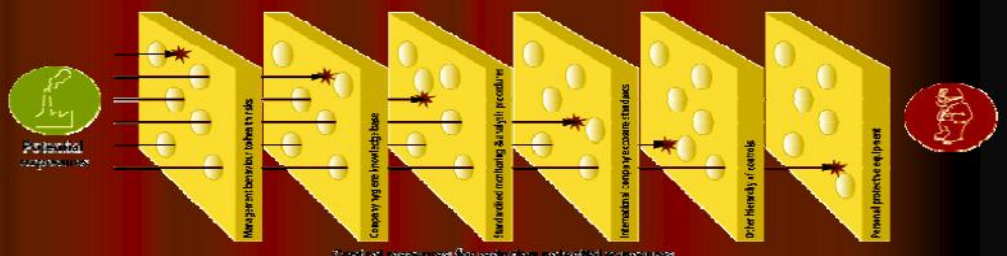
Use of PPE without knowledge and expertise can lead to an environment where many exposures could occur




# BHP PPE Health Initiative

Measures to correct PPE deficiencies and reduce employee exposures:-

- Changing Management behaviour to health risks
- Driving Quality in Occupational Hygiene practice
- Standardising monitoring and statistical analysis
- Standardising Occupational exposures
- Development of PPE compliance auditing guidelines
- Forming an alliance with major supplier to reduce noise & vibration



## Effectiveness of PPE Legislation

HSE survey reviewing the impact and effectiveness of new PPE regulations

- 35% companies problems with compliance

Other concerns identified:-

- Insufficient consultation
- Supply of inappropriate PPE
- Non Supply of PPE free of charge
- Managers reported employees not wearing PPE when instructed or not wearing it correctly

## Cost of Compliance

HSE survey also reported

- 46% of employers, none or minimal extra costs
- 50% of employers reported costs had been significant but no effect business
- 4% of employers reported cost of compliance was too high

# Limitations of PPE

OHS Reps @ work website

PPE is not an effective control

- Does not meet standards
- Not maintained
- Does not provide real protection

PPE puts onus on workers to protect themselves does not make workplace safe
PPE can make the job more difficult
PPE can impede warnings of danger
PPE can cause health problems
PPE is often not individually fitted could mean greater risk
PPE is uncomfortable causing workers to remove and not wear PPE
Training that addresses need for PPE and use not given when issued

# PPE Lazy OHS Solution

Safety at Work Blog

PPE is a lazy OHS solution because

- Many workplaces have disputes about appropriateness of PPE, which can mask better solutions
- PPE solutions sometimes long term or expensive and need to be planned for
- If a hazard requires PPE then there is always a more effective solution even though this may at the moment not be reasonably practicable

## PPE Behavior & Work Practices

Steve Mullins presentation at Behavior Based Safety Heavy Industries Conference 2007

- Management favors PPE
- Workers don't wear PPE because they hate it and because they are smart …….. not because they are lazy and forgetful
- PPE is being used in workplaces because of bad design, inadequately maintained equipment and poor work practices

## PPE Market Perspective

- PPE provides cost benefits to businesses reducing cost of work injuries and illnesses and saves lives
- PPE is in big demand because of new standards, tougher compliance and greater concern for workers safety
- PPE is proving a necessity rather than an option in many industries
- Many companies are happy to sacrifice comfort if there is a lower price option
- Industrialisation and creation of OHS legislation in developing countries is increasing demand for PPE

## PPE Future Trends

Trend towards a holistic approach to PPE

- Improvements in technology comfort and style that addresses the worker
- Value added training and support
- Integration of various types of safety equipment

Manufacturers are not just concerned of protecting one body part they are now considering how work is done and how PPE affects the person and work process

## Conclusions

PPE is complex and hazardous
Risk management and higher controls
Develop PPE program, SUCAM
Consultation with workers and suppliers
Expert knowledge
Training and Supervision, Need for PPE and
Risk perception
Accident Causation
PPE Compliance Program

## 7.5 Evaluation of Safety Gloves for Bandsaws, Peter Dowd, ANAGO 2003

# Evaluation of Safety Gloves for Bandsaws

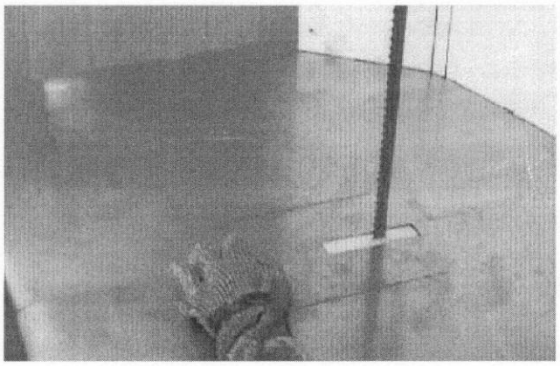
Peter Dowd, Anago Ltd
June 2003

## Goal

To determine the protective benefit offered by various types of gloves when using a Bandsaw

## Methodology

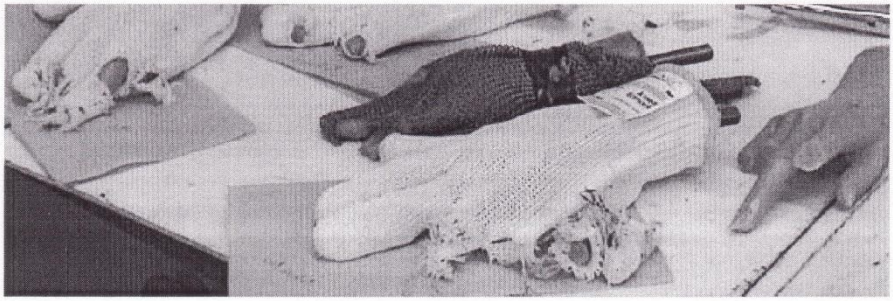
1. Dress mannequin hands in various protective gloves:
    - 1 x chain mail glove – Niroflex 2000
    - 2 x cut resistant gloves – Ansell Edmont (72-023) "SafeKnit" Max*
    - 1 x cloth glove (non-cut resistant) - unmarked
    - 1 x bare mannequin hand
2. Set up a bandsaw with a protective shield around the cutting area in case portions of gloves and/or blade scattered on impact
3. Set up a video camera to record the effects of the bandsaw blade on each glove option
4. Run the bandsaw
5. Each hand / glove combination was run across the bandsaw table and into the blade at a speed approximating that observed during normal cutting tasks
6. The effects on the glove and mannequin fingers were noted and photographs (video and still) taken of the results.



* Note that this glove contains a warning on its label "Do not use near moving or serrated blades"

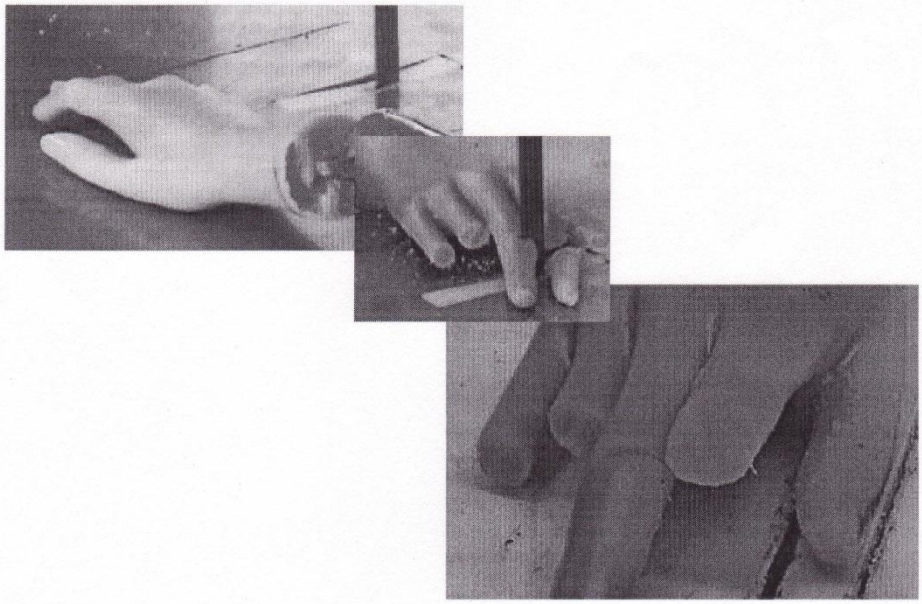
Anago Ltd, 7 Sussex St, Hamilton, NZ

## Results



### Bare mannequin hand

- Fingers were removed in a clean cut and the severed portion lay on the table near the bandsaw blade

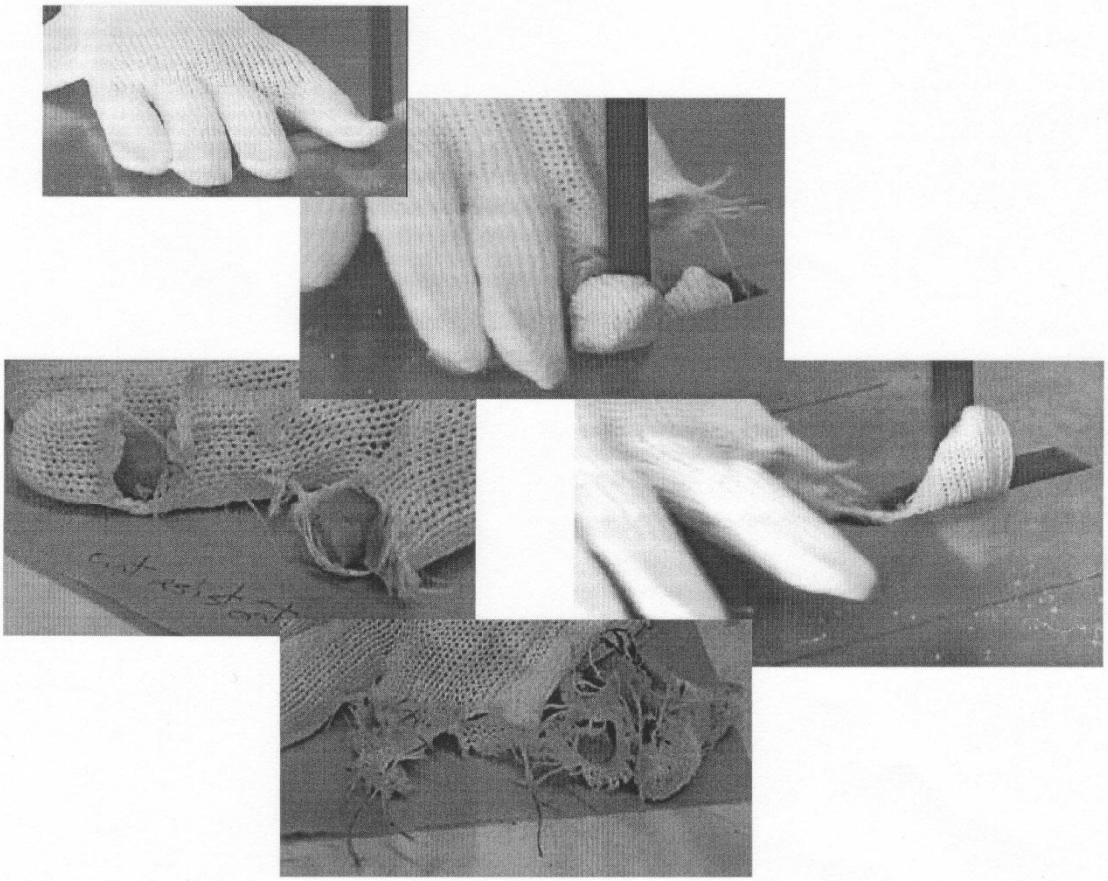


## Chain mail glove

- No detectable impedance to movement of hand through the blade
- Chain mail links were broken easily by the blade and strewn around the table
- The tip of the finger of the chain mail glove was pulled into the saw
- The cut on the finger was somewhat ragged

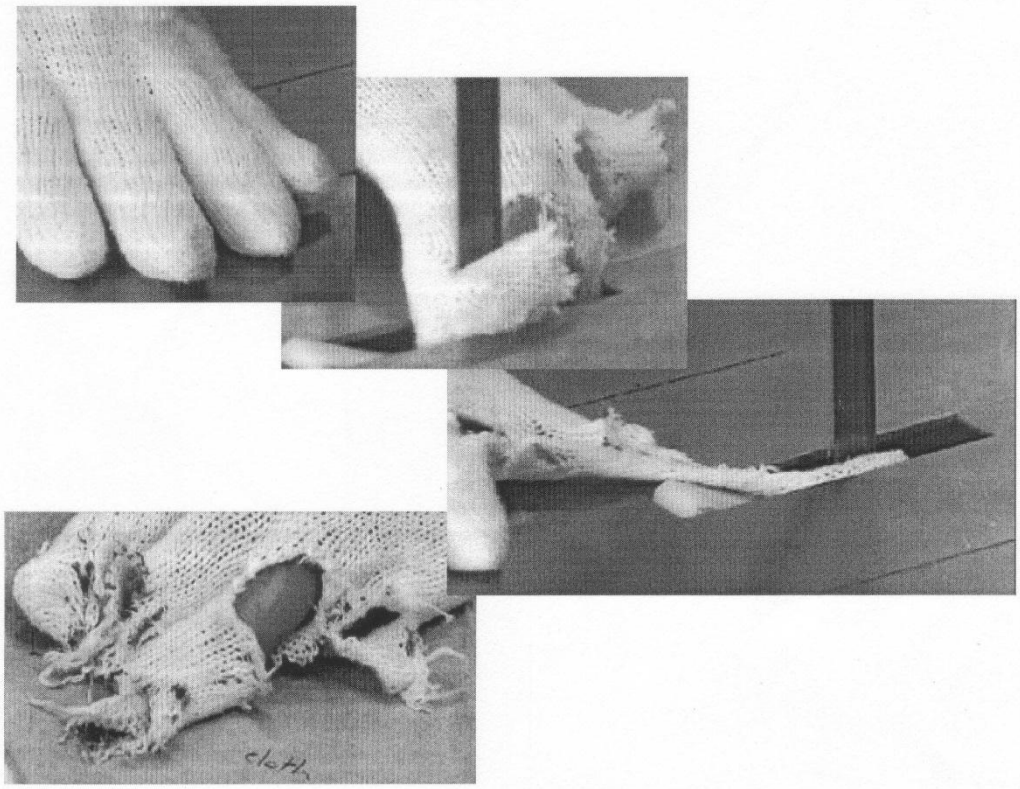
## Cut resistant gloves

- Slight impedance to amputation of multiple fingers
- Finger amputated even though glove finger tip was not full detached
- Amputated finger pulled into the bandsaw blade. This could result in considerable damage to the severed finger as it is rubbed against the bandsaw blade.
- Cut on the finger portion remaining attached to the hand was somewhat ragged
- The finger was pulled into the blade as soon as it touched it.
- The glove got stuck in the bandsaw blade and could not be removed prior to the bandsaw being stopped.



## Cloth glove

- No noticeable impedance to movement of hand through the blade
- Amputated finger pulled into the bandsaw blade
- Ragged cut on both portions of the severed finger.



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## Conclusions

- None of the gloves offered protection from amputation by the bandsaw blade
- All of the gloves resulted in the severed finger(s) being dragged into the blade. This would almost certainly result in a severely macerated finger once it was retrieved.
- The cut resistant and cloth gloves got stuck in the blade are generally could not be removed prior to the bandsaw being switched off.
- The bandsaw blade was able to catch onto the gloves and drag the gloves towards the blade, even when it may otherwise have not moved into it.
- All of the gloves resulted in a more ragged cut on the finger (severed and remaining portion) than was obtained without a glove.
- A clean cut allows the amputated finger improves the chances of a successful reattachment of the finger during surgery.

Chain mail, cut resistant and cloth gloves are not recommended for use with bandsaws.