# final report

Project code: A.OHS.0062

Prepared by: James Brennan

Design + Industry Pty Ltd

Date submitted: December 2011

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

# Bandsaw resistant glove

## New approaches to minimising bandsaw injuries in meat processing plants

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

# EXECUTIVE SUMMARY

## 1 PROMISING AREAS OF FURTHER INVESTIGATION

Design + industry believe that there are a number of areas which warrant further investigation. There are promising solutions in a ‘glove-based’ product using newly developed materials or laminar combinations of materials. Our initial testing has shown promising results to ‘glancing’ blows. Secondly, we also believe that there is significant promise in ‘environmental’ solutions…monitoring an operator’s mental state or fatigue level. Such solutions are finding acceptance in other industries where safety is of paramount importance. These solutions are now highly refined and ready for implementation and adoption by the meat industry.

These solutions may be combined with each other for additional effectiveness.

1. Glo-Mesh Armour & Polyurethane Gloves – ***pages 7-10***
2. Fluorescing gloves with a visible laser “No Go” zone – ***page 11***
3. Top & bottom glove position sensors – ***page 12***
4. Current Technology - Monitoring Systems Review
    1. Seeing Machines limited – ***page 17***
    2. SmartCap System – ***page 19***
    3. OPTALERT Fatigue monitoring – ***page 20***
5. Current Technology – Sawtooth zig zag type blade (prevents catching on chainmail) – Item 1, a), ***page 21***
6. Bandsaw blade breaking/cutting device developed for retrofit to bandsaws – easily fitted in a retrofit table top – Item 1,b), ***page 22***

## 2 CONTENTS

# 3 PREAMBLE

3.1 Setting the context – the dangers posed by bandsaws in the workplace

*"Bandsaws are a standard machine for cutting up warm & chilled meat, however they pose a significant OH&S risk. Currently, there are no suitable personal protection devices such as gloves or gauntlets suitable for bandsaws. Chainmail is suitable for knife protection, however the 6mm bandsaw teeth tend to catch and draw these into a machine. The potential safety equipment (such as a glove) needs to facilitate: quick, convenient, productive, and safe operation with operators maintaining the "feel" and adhesion of the meat product.*

*The industry has approached this problem before by way of independent solutions from individual meat processors and their maintenance departments, but so far without success."*

**Christian Ruberg,** *Meat and Livestock Association*

Design + Industry has undertaken in-depth research and explored a broad range of potential solutions to this problem.

# 4 PROJECT OBJECTIVES

4.1 Explore new methods to injury caused by bandsaws

Design + Industry (D+I) is an Industrial Design and Engineering consultancy. It is the largest of its kind in Australia, with significant reach into overseas markets. The firm is known for its work in complex electro-mechanical design. It is a Registered Research Agency (RRA).

**Design + Industry RRA registration number is 13279**

A Registered Research Agency (RRA) is an organisation with technical or scientific expertise in a specific class of Australian research and development (R&D). RRA status is conferred by the Innovation Australia Board (the Board) in one or more classes of Australian R&D activity. The Board's approval recognises that the RRA can perform contract R&D work on behalf of companies eligible to claim the R&D Tax Concession or on behalf of a group of companies where collaborative arrangements are in place.

# **5** METHODOLOGY

## 5.1 Research and Site Visits

D+I conducted extensive desk research, a site visit to the Dinsmore facility of the JBS Group in Queensland, consulted extensively with materials suppliers and manufacturers of Personal Protective Equipment (PPE). This process allowed us to establish the environment of use together with an understanding of the physical, mental and procedural limitations that any solution may be required to conform to.

The MLA is looking for a solution that can be adopted industry wide, gaining acceptance without imposing a significant financial burden on meat processing plants. Therefore, in addition to 'glove-based' solutions we have also looked at alternatives that involve minimal cost in retro-fitting machinery, or areas of new technology (used in other industries) that show promise and could be successfully adapted for use in meat-processing plants

The following is a summary of solution areas that deserve consideration and possibly further development. We broke our research and report findings into 'discreet' areas of activity and investigated a wide range of glove-based solutions together with promising technologies and approaches in other areas

## 5.2 AREAS OF INVESTIGATION

**Section 1: Glove based Solutions**

**Section 2: Hand Position Sensing Solutions**

**Section 3: Meat Holding Jigs**

**Section 4: 'Captain Hook' Claw style devices**

**Section 5: Eye-Tracking Monitoring**

**Section 6: Operators Mental State Monitoring**

**Section 7: New Saw Blade Technologies**

*Areas where solutions were not proposed, but that showed promise*

Appendix A: **Machine Intervention Technologies**

# RESEARCH RESULTS

## 6 SECTION 1: GLOVE STYLE SOLUTION

### 6.1 A Standalone Protective Glove Solution

The broad concept is for a flexible, super tough glove in some material or combination of materials. There are quite a number of materials able to resist a bandsaw blade and if these could be combined into some kind of edgeless or homogeneous surface, the shielded glove approach is valid. The approach would be to design a configuration of blade profile and glove surface that ‘deflects’ rather than ‘grabs’. The ‘Go-Mesh’ solution offers a lot of promise because each individual ‘scale’ has a raised surface with a radiussed edge that should not provide an easily accessible grab point.

### 6.2 Possible glove configurations

1. Super tough flexible materials that will resist glancing and short term engagement with the bandsaw blade.
2. Super tough flexible materials combined with secondary blade resisting substrates
3. A high tensile “Glo-Mesh” metal weave to replace chainmail
4. Chainmail with links so small that the teeth of the saw would not catch
5. Fine woven wire mesh
6. Very thin steel sheet in segmented pieces like fish scales

## SECTION 1: GLOVE STYLE SOLUTION

### Alternate Glove – Currently Available - Non Metallic - Toughest Example Found


Click Image to play video

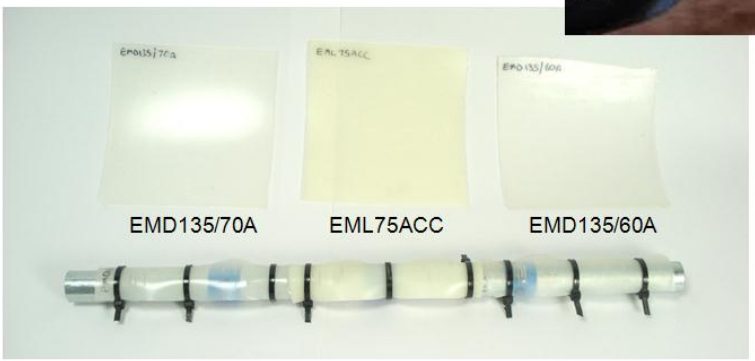
## SECTION 1: GLOVE STYLE SOLUTION

### Super Tough, Flexible Polyurethane Resin

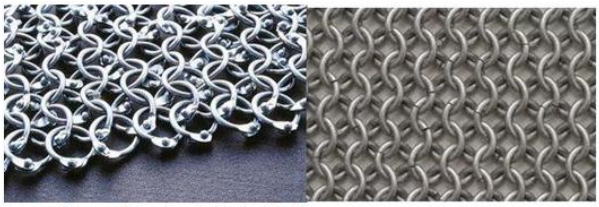
- Can Be Combined With Metal Substrates to produce saw resistant gloves

In the search for super tough materials, polyurethane was identified as potentially capable of short term resistance to the bandsaw blade. Recommendations were made by a polyurethane chemistry specialist and preliminary tests were conducted on samples provided. The EML75ACC sample results were encouraging.

Click Image to play video

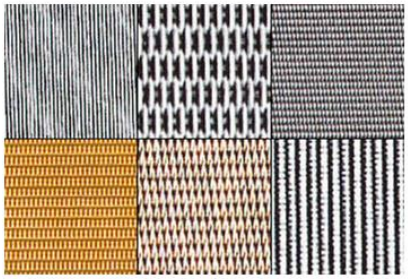



## SECTION 1: GLOVE STYLE SOLUTION
### Alternative Glove - Metal Media

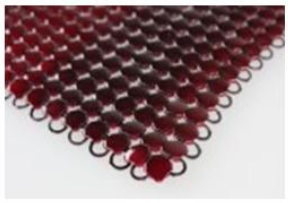


Super Strong Riveted Chain Mail  Fine Standard Chain Mail

Glo-Mesh Metal Fabric – available in stainless steel



Fine Woven Wire Mesh



## SECTION 1: GLOVE STYLE SOLUTION
### Alternative Glove Protection

Leather Style Protection

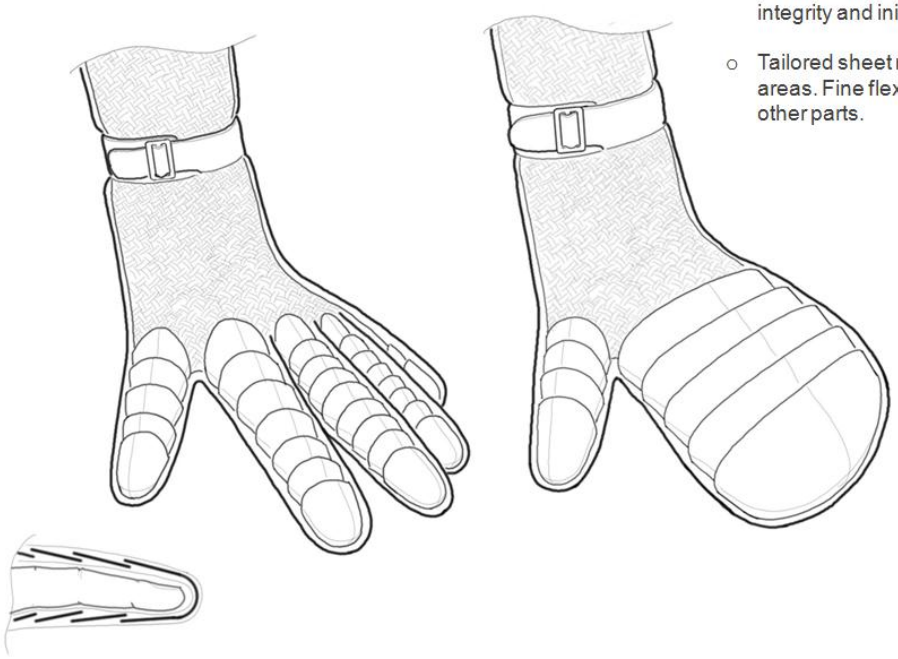

Metal Gauntlet Style Protection


## SECTION 1: GLOVE STYLE SOLUTION

### Alternative Glove Protection

### - Sheet metal Armour & Polyurethane Gloves

- The flexible Polyurethane provides glove integrity and initial saw blade resistance.
- Tailored sheet metal shields cover high risk areas. Fine flexible chainmail mesh covers other parts.

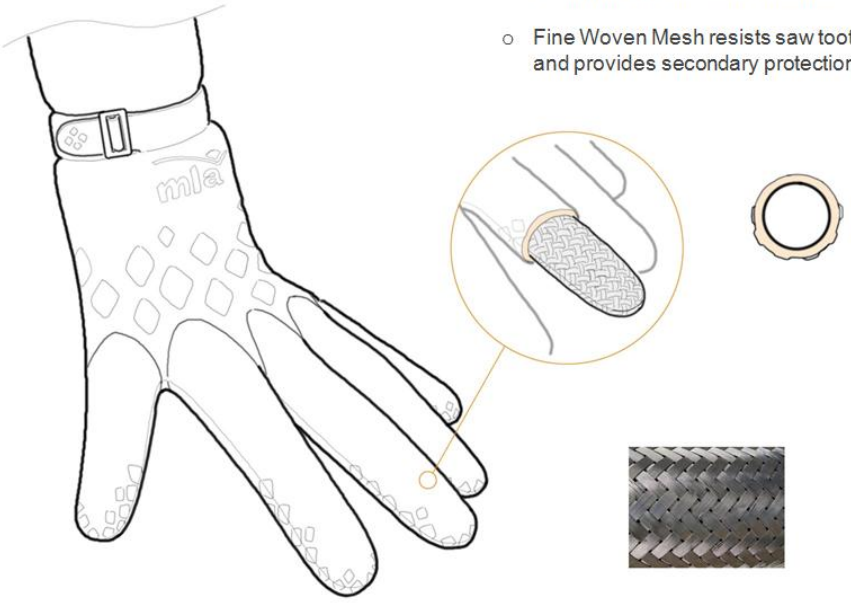


## SECTION 1: GLOVE STYLE SOLUTION

### Alternative Glove Protection

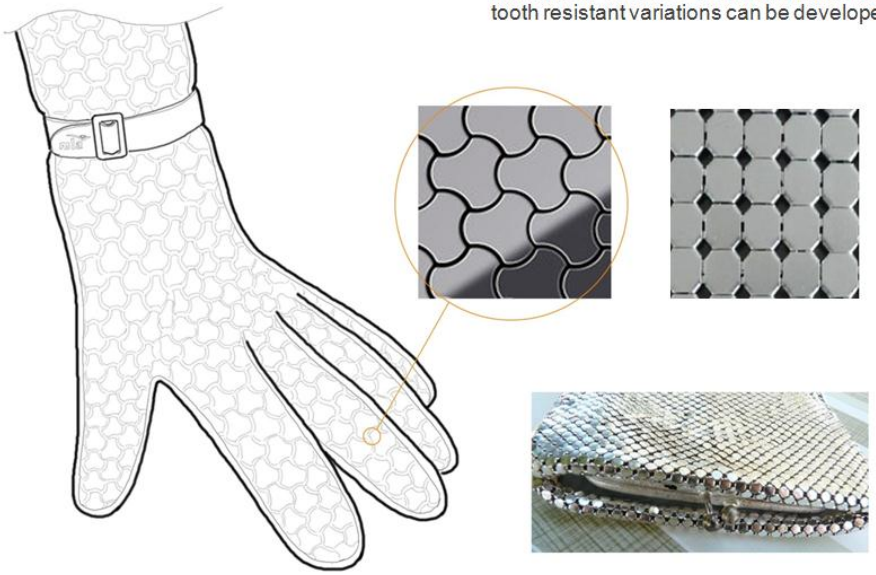
### - Fine Woven mesh & Polyurethane Gloves

- The flexible Polyurethane provides glove integrity and initial saw blade resistance.
- Fine Woven Mesh resists saw tooth entrapment and provides secondary protection



SECTION 1: GLOVE STYLE SOLUTION
Alternative Glove Protection
- Glo-Mesh Armour & Polyurethane Gloves

- The flexible Polyurethane provides glove integrity and initial saw blade resistance.
- The rounded edges of the Glo-Mesh links resist saw tooth entrapment and provide sturdy secondary protection. Square patterns are available in Stainless Steel right now. Other more tooth resistant variations can be developed.



## 7 SECTION 2: HAND POSITION SENSING

### 7.1 Retrofit Hand Position Sensing Equipment

The use of hi tech sensing solutions to create a “NO GO” zone around the saw blade for operator gloved hands.

These solutions could be retrofitted to both the saw head and also the saw table (false working surface) if necessary.

These solutions would need to be coupled with a saw blade stopping mechanism.

a) Fluorescing glove with visible laser barrier

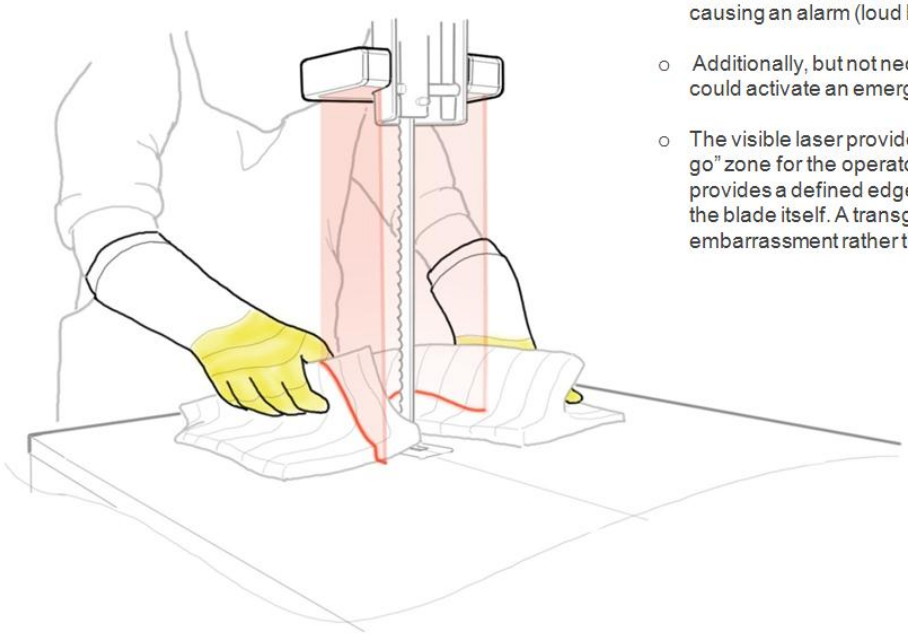
b) Other glove embedded position sensors above and in a false bed on the bandsaw

c) Glove and Blade contact sensing (see “saw stop”)

## SECTION 2: HAND POSITION SENSING

### Retrofit Hand Position Sensing Equipment

### - Fluorescing gloves with a visible laser "No Go" zone

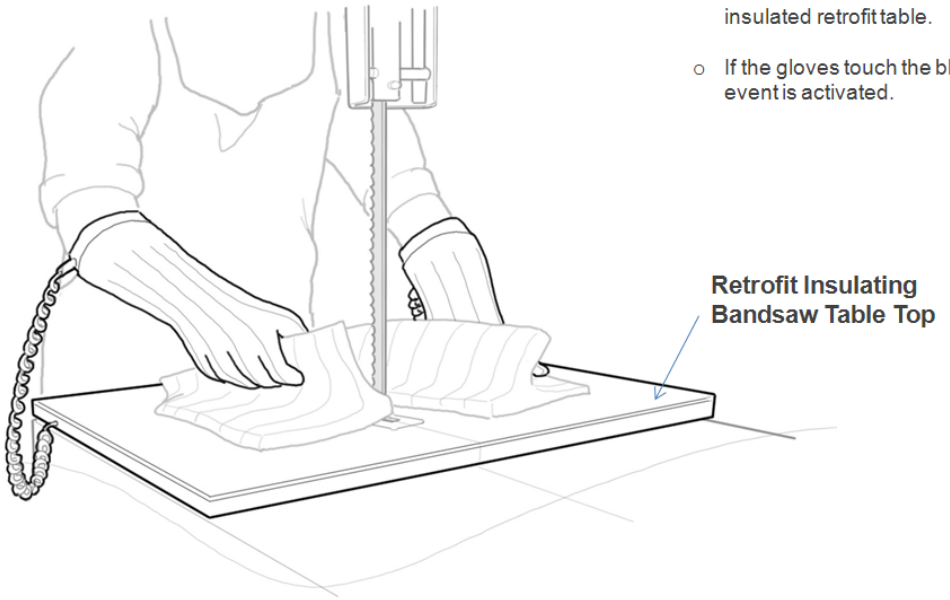


- If the gloves move inside the laser barrier, they fluoresce, triggering a sensor and causing an alarm (loud horn or similar).
- Additionally, but not necessarily, the bandsaw could activate an emergency "stop".
- The visible laser provides a clear safety "no go" zone for the operators hands. This provides a defined edge to avoid rather than the blade itself. A transgression causes embarrassment rather than injury.

## SECTION 2: HAND POSITION SENSING

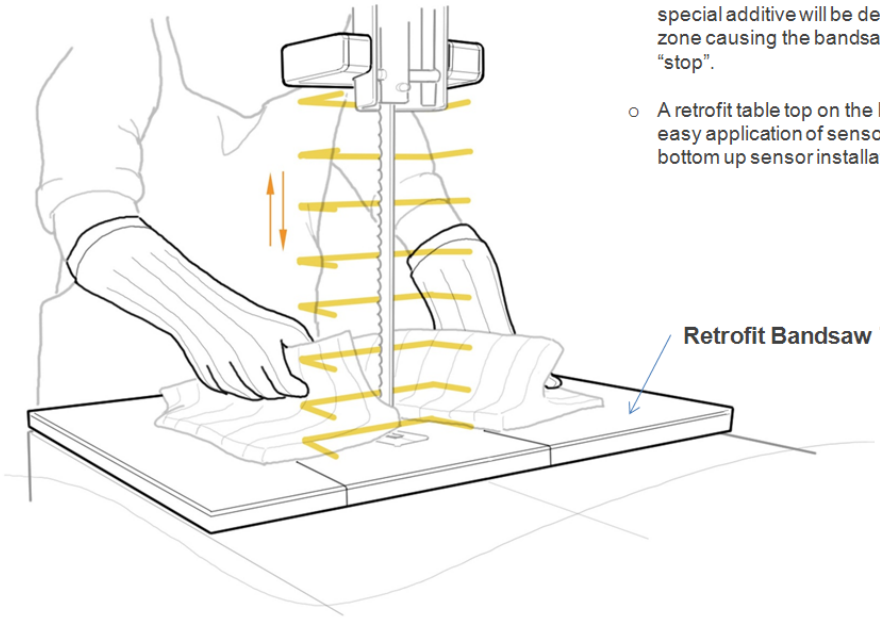
### Retrofit Hand Position Sensing Equipment

### - Glove to Blade touch sensing




- Gloves are electrically connected and carry a unique signal or frequency.
- The bandsaw and blade are isolated by a insulated retrofit table.
- If the gloves touch the blade a "Blade Stop" event is activated.

SECTION 2: HAND POSITION SENSING
Retrofit Hand Position Sensing Equipment
- Top & bottom glove position sensors




- Proximity sensors not triggered by meat & bone create a "No Go" zone. Gloves with a special additive will be detected if entering the zone causing the bandsaw to activate a "stop".
- A retrofit table top on the bandsaw provides easy application of sensor reflective media or bottom up sensor installation.

# 8 SECTION 3: MEAT HOLDING JIGS

## 8.1 Custom Meat Holding Jigs - For Remote Hand Position

Jigs that clamp onto the meat and ensure the operators hands are well clear of the blade during the cut. Dead-man's handles may also be employed. These solutions need not be complicated or linked to the saw bench.

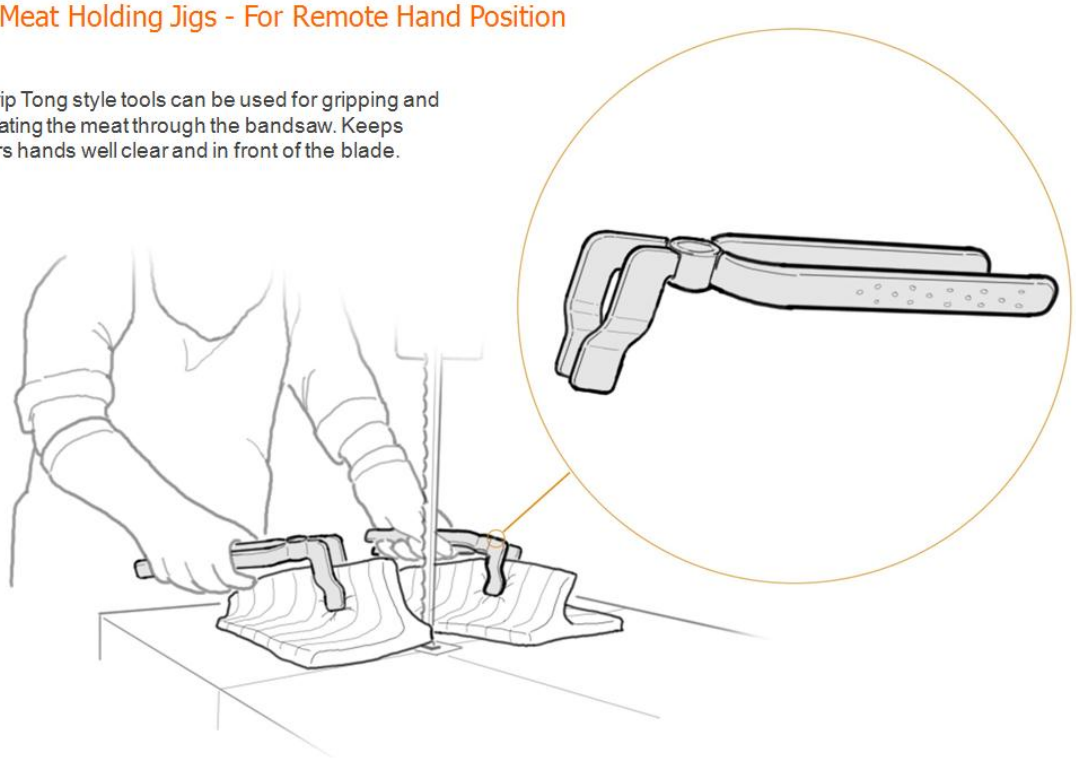
a) Cradle style jigs using quick clamps and saw bed guides with "dead-man's" handles.

b) Freestyle clamps or grips (think latching Bar-B-Que tongs) that allow manipulation of the meat while keeping the operators hands well clear or in front of the saw blade

## SECTION 3: MEAT HOLDING JIGS

### Custom Meat Holding Jigs - For Remote Hand Position

- Snap Grip Tong style tools can be used for gripping and manipulating the meat through the bandsaw. Keeps operators hands well clear and in front of the blade.



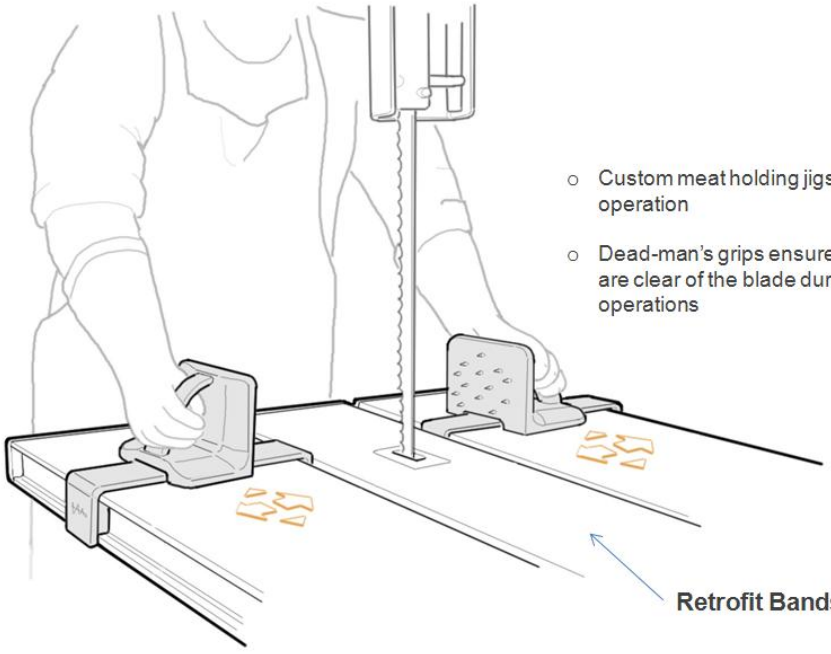
Further refinement of the jigs proposal might include the analysis of the upstream and downstream activities involved. There might be an efficient team that assists the mounting and dismounting of the animal carcass, with the bandsaw operator only required to ‘cut’, not perform the whole operation.

## SECTION 3: MEAT HOLDING JIGS
### Some Existing Examples

Freestyle Grips – shield hands from the blade

Sliding Table Bandsaws – adaptable to meat holding jigs

## SECTION 3: MEAT HOLDING JIGS
### Custom Meat Holding Jigs - For Remote Hand Position




- Custom meat holding jigs for each cut operation
- Dead-man's grips ensure the operators hands are clear of the blade during cutting operations

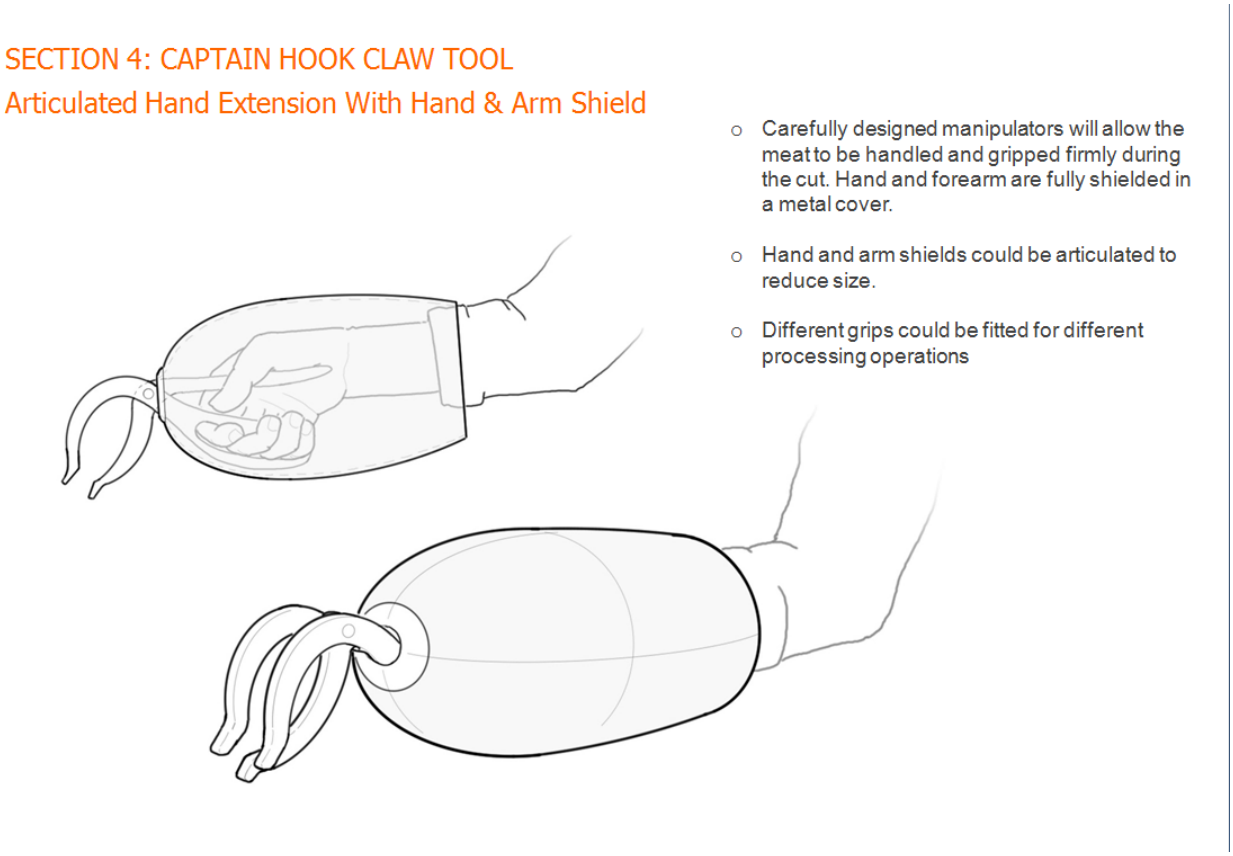
# 9 SECTION 4: CAPTAIN HOOK CLAW TOOL

## 9.1 Articulated Hand Extension With Hand & Arm Shield

The articulated hand extension that allows ready gripping and manipulation of the meat while providing a full metallic shield for the hands. Some training and practice may be required. Used by other industries for handling hot and other dangerous articles.

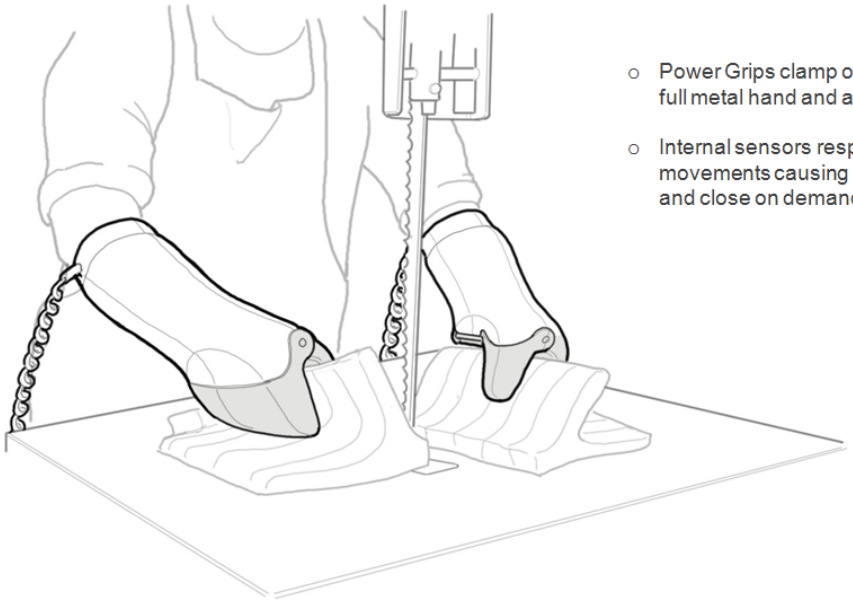
a) Think large pliers with the handles covered by a shroud

b) Think robot hand manipulators with metallic arm shell




Many other industries (such as glass-blowing) have employed such solutions. These are encouraging because of the ‘adaptive’ nature of human dexterity in the workplace. After a short time, even quite complex and delicate operations can be performed quickly and routinely.

## SECTION 4: CAPTAIN HOOK CLAW TOOL
### Articulated Hand Extension With Hand & Arm Shield



- Power Grips clamp onto the meat providing a full metal hand and arm guard
- Internal sensors respond to finger and thumb movements causing the Power Grips to open and close on demand.

SECTION 4: CAPTAIN HOOK CLAW TOOL
Articulated Hand Extension With Hand & Arm Shield


Various Grips that could be used with a fully shielded hand

# 10 SECTION 5: EYE TRACKING MONITOR

10.1 Track the operators eye position to ensure their focus is on the cut

SECTION 5: EYE TRACKING MONITOR

Current Technology - Seeing Machines limited


Click Image to play video

SECTION 5: EYE TRACKING MONITOR

Current Technology from Seeing Machines limited


The Seeing Machines DSS suite is a robust, automatic platform that uses cutting edge face tracking techniques to deliver information on operator fatigue and operator distraction. The DSS has been specifically designed for straightforward deployment into vehicles & environments where fatigue and inattention need to be monitored and managed.

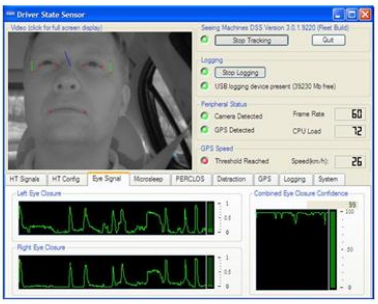
Media:

DSS Demonstration Video

DSS Screenshot

Downloads:

DSS Brochure





Flexible solutions to meet your business needs

- Manage Driver Fatigue
- Detect Driver Distraction
- Fully Automatic, Non-contact
- Real-Time Driver Feedback

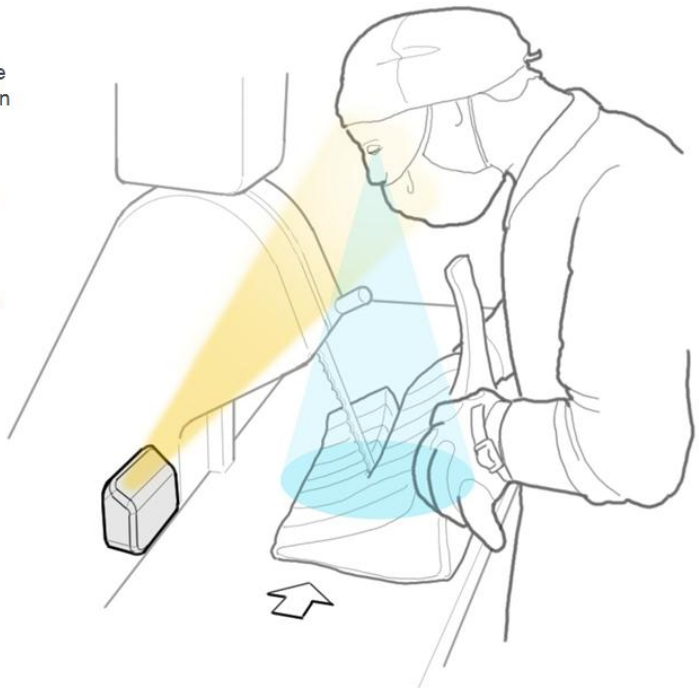
DSS Capabilities

The DSS-IVS (in vehicle system) measures the eyelid opening of the driver, and based on this data derives the drowsiness state. No sensors need to be worn by the driver; a remote sensor on the dashboard observes the face of the driver and measures eyelid closure. There is also no calibration procedure required for new drivers. This means any driver can get behind the wheel without any time consuming calibration, annoying sensor attachment process, or any special knowledge about the system.

## SECTION 5: EYE TRACKING MONITOR

### Track The Operators Eye Position To Ensure Their Focus Is On The Cut

- The Eye Tracking technology will only let the bandsaw run when the operators eyes are in the work zone.
- Fatigue can also be monitored using established algorithms based on blink time and rate.
- Central reporting of fatigue will initiate operator swap-out and also be logged to an operator's performance record.



These solutions are readily adaptable and transferrable from other applications. The potential is there to easily adapt these technologies to retro-fit to existing machines. Existing installations can be fitted for the order of $2.2 K. D+I have spoken to the system designers and they are confident that a 'detuned' version could be produced to reduce this cost (if required)

# 11 SECTION 6: OPERATORS MENTAL STATE MONITORING

## 11.1 Identify High Risk Mental States In Operators

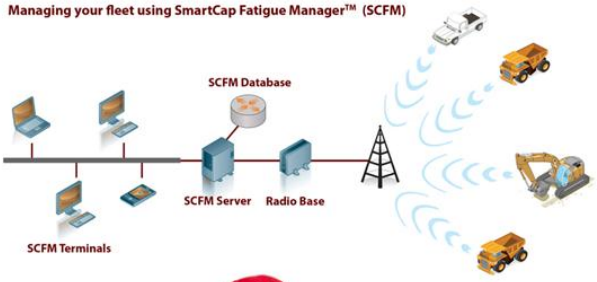
Current unobtrusive technologies are able to identify the mental state of the operator through brain wave monitoring. This would allow operators to be swapped out before accidents happen. Management can be involved in an active monitoring role. Individual or site data can be aggregated. Used in other industries as an accident prevention strategy.

a) Identify fatigue, sleepiness, agitation & anger

b) Discrete monitoring device is worn by the operator

SECTION 6: OPERATORS MENTAL STATE MONITORING

Current Technology – SmartCap System




Click Image to play video

## SECTION 6: OPERATORS MENTAL STATE MONITORING
### Current Technology – OPTALERT Fatigue monitoring



Click Image to play video

## SECTION 6: OPERATORS MENTAL STATE MONITORING
### Identify High Risk Mental States In Operators

- The Monitor generates a local alarm to alert the operator that they are at a dangerous fatigue level.
- An alarm is also triggered with the Section Supervisor so that a replacement operator can be organised.
- Fatigue alerts are logged at the site office and are assigned to the operator's record.

## 12 SECTION 7: NEW SAW BLADE TECHNOLOGIES

### 12.1 Look at alternatives to the current barb type blade

Look at alternatives to the current barb type blade to make chainmail and/or other gloves more effective in preventing accidents.

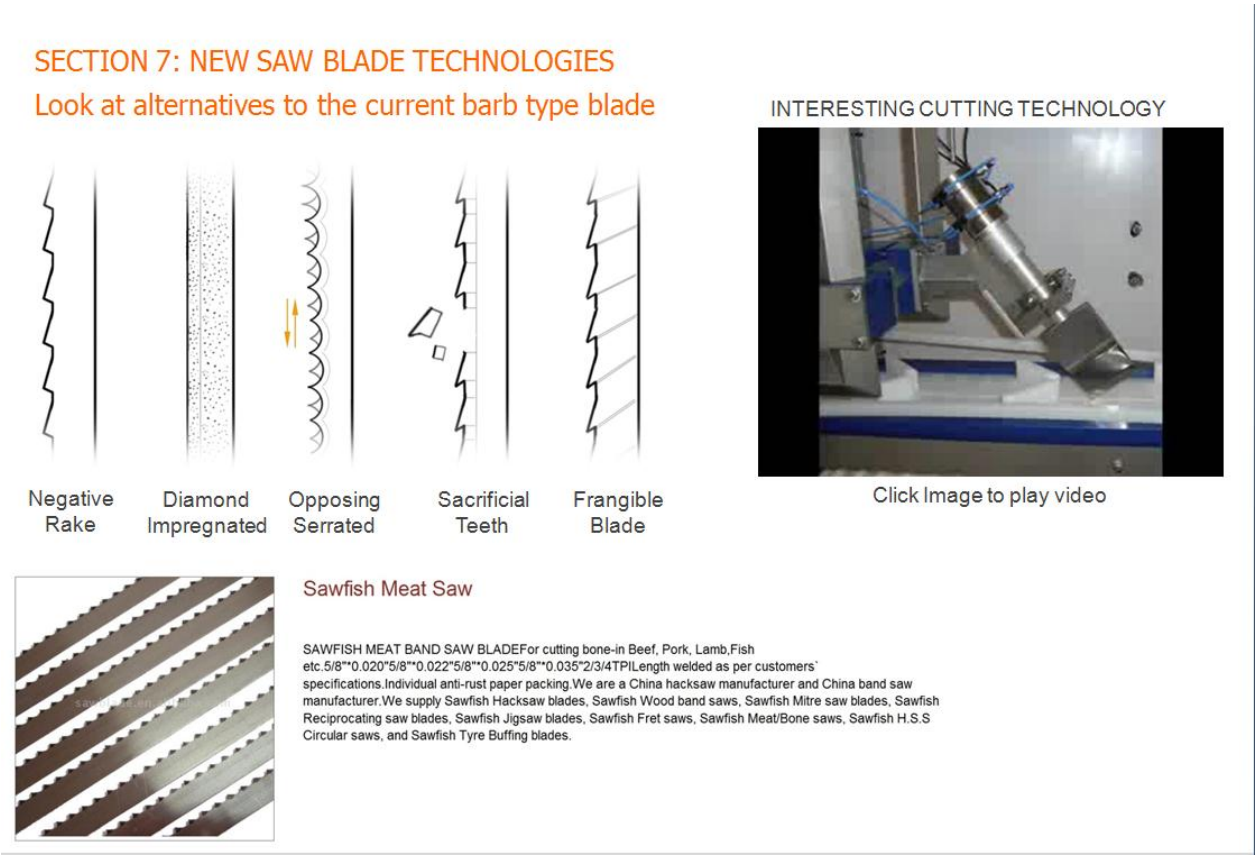
a) Sawtooth zig zag type blade (prevents catching on chainmail)

b) Diamond impregnated blades (available now, possibly slow, will lose diamond particles into the meat)

c) Opposing scalloped blades like an electric knife (new product, possibly not good with bone)

d) Sacrificial teeth – snap off if chainmail is caught (replace blade & clean Bandsaw after event)

e) Frangible blades – will snap if overloaded or jammed (by chainmail gloves etc)

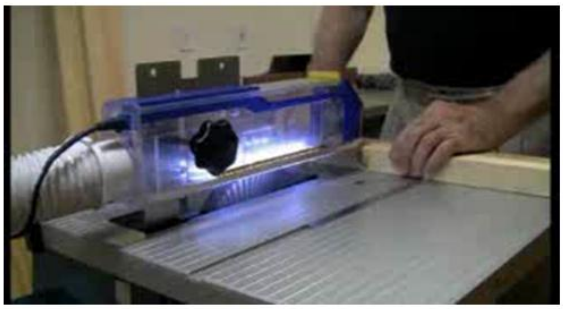


# 13 APPENDIX A: DAMAGE PREVENTION TECHNOLOGIES

## 13.1 WAYS TO MINIMISE DAMAGE IF SENSORS ARE TRIGGERED

1. SAW STOP TECHNOLOGY – A number of saw stopping devices exist for circular saws. Some do not damage the saw.
    a) Saw Stop or similar – see video on the following page.
    b) Bandsaw blade breaking/cutting device developed for retrofit to band saws – easily fitted to retrofit table top
2. ELECTRIC MOTOR BREAKING – rapid stop of saw blade by putting a stop brake on the motor.
    a) Convert bandsaw electric motors with quick stop electronic brake circuits.
    b) Very rapid mechanical saw stop – no saw damage – immediate restart – retrofit application.

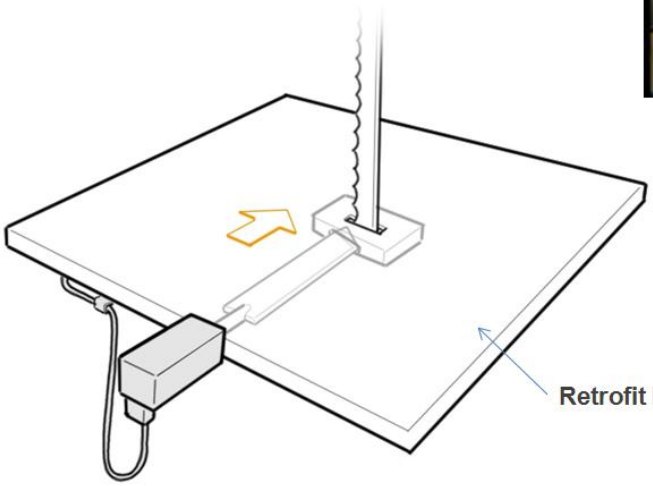
APPENDIX A: DAMAGE PREVENTION TECHNOLOGIES
Ways To Minimise Damage If Sensors Are Triggered



Click Image to play video

A "Saw Stop" Variation for circular saws

Retrofit Bandsaw Blade cutting device (solenoid)



Retrofit Bandsaw Table Top Assembly

## 13.2 INVOLUNTARY MUSCLE CONTRACTION

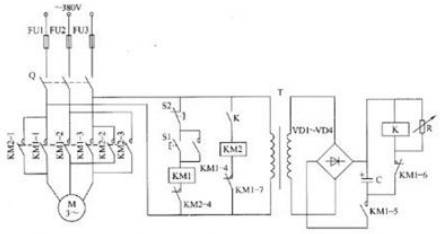
Involuntary or forced muscle contraction in the arms to immediately remove hands from danger.

c) Involuntary, as per touching of a hot surface. Nerves interact via the spinal cord directly with arm muscles. Stimulate by heat, sound, light or other stimuli.

d) Force muscle retraction by electrodes in arm sleeve apparel

## APPENDIX A: DAMAGE PREVENTION TECHNOLOGIES

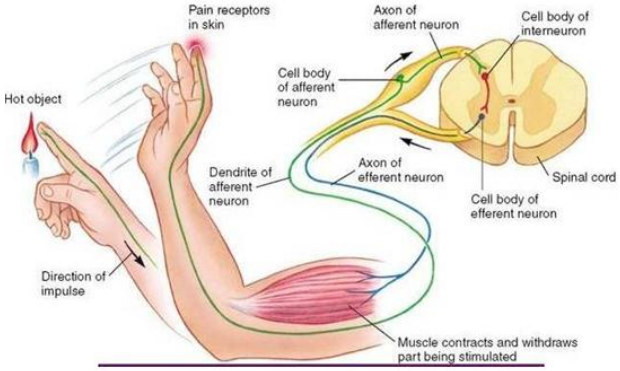
### Ways To Minimise Damage If Sensors Are Triggered



**Electrical Braking**

Electrical braking uses the windings of the motor to produce a retarding torque. The kinetic energy of the rotor and the load is dissipated as heat in the rotor bars of the motor. Two means of electrical braking are plugging and dynamic breaking.
Plugging brings an induction motor to a very quick stop by connecting the motor for reverse rotation while it is running. To prevent the motor from reversing after it has come to a stop, the power is removed by means of a zero speed switch.
Dynamic braking is achieved by removing the AC power supply from the motor and applying direct current to one of the stator phases.
Neither plugging nor dynamic braking can hold the motor stationary after it has stopped.

**Triggering of Involuntary Reactions in humans**




- **Involuntary Reactions can be induced by providing the right stimulus or by the appropriate application of an electrical current to a muscle group.**
- While this is an interesting concept, the invasiveness of this approach is unlikely to gain the necessary support to be affective.

## CONCLUSIONS AND RECOMMENDATIONS

### 13.3 PROMISING AREAS OF FURTHER INVESTIGATION

Design + industry believe that there are a number of areas which warrant further investigation. There are promising solutions in a ‘glove-based’ product using newly developed materials or laminar combinations of materials. Our initial testing has shown promising results to ‘glancing’ blows. Secondly, we also believe that there is significant promise in ‘environmental’ solutions…monitoring an operator’s mental state or fatigue level. Such solutions are finding acceptance in other industries where safety is of paramount importance. These solutions are now highly developed and ready for implementation and adoption by the meat industry.

These solutions may be combined with each other for additional effectiveness.

1. Glo-Mesh Armour & Polyurethane Gloves – ***pages 7-10***
2. Fluorescing gloves with a visible laser “No Go” zone – ***page 11***
3. Top & bottom glove position sensors – ***page 12***
4. Current Technology - Monitoring Systems Review
    i. Seeing Machines Limited – ***page 17***
    ii. SmartCap System – ***page 19***
    iii. OPTALERT Fatigue monitoring – ***page 20***
5. Current Technology – Sawtooth zig zag type blade (prevents catching on chainmail) – Item 1, a), ***page 21***
6. Bandsaw blade breaking/cutting device developed for retrofit to bandsaws – easily fitted in a retrofit table top – Item 1,b), ***page 22***