final report

Project Code: PRTEC.006

Prepared by: Jeff Owen

Date published: May 2004

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

Sheep Jaw Opening Tool (and Plugging)

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.

Introduction to Project

In 1997 Australian Meat Technology Pty Ltd (AMT) engaged CSIRO Food Science and Technology (now trading as Food Science Australia) to develop an internal oesophagus sealing system for sheep. CSIRO and AMT had previously developed an internal beef oesophagus sealing system (Plugging) and this technology was modified and scaled down to suit sheep.

As with the beef plugging, this project was intended to provide an improved method of oesophagus sealing without the risk of contamination associated with entering the body through the hide. This previous project resulted in a suitable plug design and applicator, which was successfully tested at the CSIRO Cannon Hill slaughter floor. A single cavity plastic injection die was manufactured to allow a larger number of plugs to be produced for works trials.

At that point, the CSIRO involvement in the project concluded. For humane reasons, most trials at Cannon Hill were carried out using a captive bolt stunner to avoid the possibility of animals recovering during trials. Lockjaw of electrically stunned animals had been identified as a possible problem and a simple tool was manufactured to force the mouth open. Several electrically stunned sheep were successfully plugged using this tool. While this tool can be used to open the mouth, it is too slow and awkward for use in an abattoir, in its present state.

Electrically stunned sheep can tilt their head down and pull the head back towards the body. This reaction results in the oesophagus assuming a severe "S" bend with changes of direction just past the mouth and at the entry to the thoracic cavity. AMT staff indicated that they would address the lockjaw issue during more extensive works trials. Lockjaw and muscle contraction issues were not resolved before AMT ceased to trade.

Project Objectives

The project, Sheep Jaw Opening System – PRTEC.006 consists of 2 parts as follows:

1. Develop a method and equipment to open the mouth of electrically stunned sheep, to allow the insertion of an oesophagus sealing plug.
2. Conduct and evaluate plugging trials with the original AMT plugger. This piece of equipment will require extensive remanufacture or replacement before trials can be conducted.

Conclusions

Works trials have shown the mouth opening tool concept developed during this project can reliably and consistently open the mouth of electrically stunned sheep.

These trials have shown that it is highly unlikely that plugs can be consistently and reliably inserted into the oesophagus of sheep stunned with a conventional electric stunner. This is due to the muscle contraction in the

[1] Majority of text extracted from Project reports

neck region. The trials with captive bolt stunning clearly showed the benefit of oesophagus plugging non-electric stunned sheep.

The process is more convenient, faster and, if a suitable method of stunning is found, more readily integrated into existing plants. Correctly applied oesophagus plugs provide an effective seal. There is a zero tolerance on contamination from paunch contents, and the plugs provide a seal before any entry is made to the body cavity.

They also prevent contamination of the blood during bleeding. It is recommended that alternatives to conventional electric stunning be investigated. Technology being developed in an existing MLA project, PRTEC.013 Automating the Cattle Knocking Box by Using Electronic Stunning, may also be a suitable application for sheep. One of the objectives of this project is to provide electric stunning without subsequent muscle activity.

Results

From these trials it was found that the mouth-opening tool was able to successfully open the mouth in approximately 75% of attempts in Trial#12, and virtually all attempts in Trial#13. In the cases where the tool was unable to open the mouth, it was due to insufficient torque from the rotary actuator. As the tool has clearly demonstrated the mouth opening concept, it was decided that remanufacturing the existing tool for a more powerful actuator was not warranted.

The results from Objective 1 of this project (Trial#8) showed that resistance at the back of the head may be a problem, however, a high rate of success could be expected. Trial#8 was carried out using a piece of 20mm diameter tube to simulate plug insertion. Trial#12 and Trial#13 did not produce the expected results. Considerable resistance was felt at the back of the neck. In Trial#13, only 13 of the 46 recorded attempts achieved insertion, and only 5 of these resulted in a correctly applied plug. The other 7 attempts resulted in the plug remaining attached to the tool when it was withdrawn. This is an indication that the plug was pushed out through the oesophagus and into the body. The issue of pushing out through the oesophagus did not show up in Trial#8 as the Halal cut and subsequent processing tend to remove the evidence.

Electric stunning not only has the result of clamping the mouth shut, but also tightens the muscles in the neck and pulls the chin down and back. This produces a severe bend at the back of the head (See Figure 3). This bend obstructs the successful insertion of the plug.

Where to from here?

The three options for this project are:

1. Wait for the “lightning bolt stunning” work to be completed (estimated 2 years)
2. Look at a different style of plug
3. Develop a flexible rodding tool.

A plant initiate project has been developed for option 3 at a total cost of $80,000 (total project price) including the host site owning a flexible rodding tool and jaw opening device.

Sean Starling

Program Manager - Process and Systems Engineering
Meat and Livestock Australia
165 Walker Street
(Locked Bag 991)
North Sydney NSW 2059
Phone (02) 9463 9197
Fax (02) 9463 9182
Mobile 0419 89 1950
sstarling@mla.com.au
www.mla.com.au

MILESTONE REPORTS

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC

CSIRO AFISC Australian Food Industry Science Centre

Sheep Jaw Opening System – PRTEC.006

Objective 2 Report

AMPC

MEAT & LIVESTOCK AUSTRALIA

Prepared for: Meat & Livestock Association
Australian Meat Processor Corporation Ltd

Prepared by: Jeff Owen, Researcher

Date: 28th October 2002

EXECUTIVE SUMMARY

The project, Sheep Jaw Opening System – PRTEC.006 consists of 2 parts as follows:

1. Develop a method and equipment to open the mouth of electrically stunned sheep, to allow the insertion of an oesophagus sealing plug.
2. Conduct and evaluate plugging trials with the original AMT plugger. This piece of equipment will require extensive remanufacture or replacement before trials can be conducted.

The first part of this project has been completed and has been included as APPENDIX B – OBJECTIVE ONE REPORT, for readers not familiar with the history of this project.

The second part of this project forms the basis of this report.

Works trials have shown the mouth opening tool concept developed during this project can reliably and consistently open the mouth of electrically stunned sheep.

These trials have shown that it is highly unlikely that plugs can be consistently and reliably inserted into the oesophagus of sheep stunned with a conventional electric stunner. This is due to the muscle contraction in the neck region.

The trials with captive bolt stunning clearly showed the benefit of oesophagus plugging non-electric stunned sheep. The process is more convenient, faster and, if a suitable method of stunning is found, more readily integrated into existing plants.

Correctly applied oesophagus plugs provide an effective seal. There is a zero tolerance on contamination from paunch contents, and the plugs provide a seal before any entry is made to the body cavity. They also prevent contamination of the blood during bleeding.

It is recommended that alternatives to conventional electric stunning be investigated.

Technology being developed in an existing MLA project, PRTEC.013 Automating the Cattle Knocking Box by Using Electronic Stunning, may also be a suitable application for sheep. One of the objectives of this project is to provide electric stunning without subsequent muscle activity.

Table Of Contents

1. INTRODUCTION

In 1997 Australian Meat Technology Pty Ltd (**AMT**) engaged CSIRO Food Science and Technology (now trading as Food Science Australia) to develop an internal oesophagus sealing system for sheep. CSIRO and AMT had previously developed an internal beef oesophagus sealing system (**Plugging**) and this technology was modified and scaled down to suit sheep.

As with the beef plugging, this project was intended to provide an improved method of oesophagus sealing without the risk of contamination associated with entering the body through the hide.

This previous project resulted in a suitable plug design and applicator, which was successfully tested at the CSIRO Cannon Hill slaughter floor. A single cavity plastic injection die was manufactured to allow a larger number of plugs to be produced for works trials. At that point, the CSIRO involvement in the project concluded.

For humane reasons, most trials at Cannon Hill were carried out using a captive bolt stunner to avoid the possibility of animals recovering during trials. Lockjaw of electrically stunned animals had been identified as a possible problem and a simple tool was manufactured to force the mouth open. Several electrically stunned sheep were successfully plugged using this tool. While this tool can be used to open the mouth, it is too slow and awkward for use in an abattoir, in its present state.

Electrically stunned sheep can tilt their head down and pull the head back towards the body. This reaction results in the oesophagus assuming a severe “S” bend with changes of direction just past the mouth and at the entry to the thoracic cavity. AMT staff indicated that they would address the lockjaw issue during more extensive works trials.

Lockjaw and muscle contraction issues were not resolved before AMT ceased to trade.

2. PROJECT OBJECTIVES

Objective 1. (Completed)

Objective 2 (The basis of this report)

1. Develop a proof of concept prototype plugging tool by either modifying the AMT device, or developing a new prototype tool
   This device will preferably have the following features and capabilities:
   - Hand held
   - Suitable for trials at the Food Science Australia, Cannon Hill slaughter floor
   - Suitable for limited works trials
   - Allow one person to open the jaw and apply the plug
   - Be compatible with existing processing facilities
   - Operate at line speed or at least demonstrate the potential to do so

2. Undertake works trials with the mouth opener and plug applicator tools.

3. METHODOLOGY

The original AMT plugging concept was for a flexible tool to be used to insert the plug close to the gastro-oesophageal junction. This resulted in a relatively complex tool that is heavy and cumbersome to use (Figure 1).

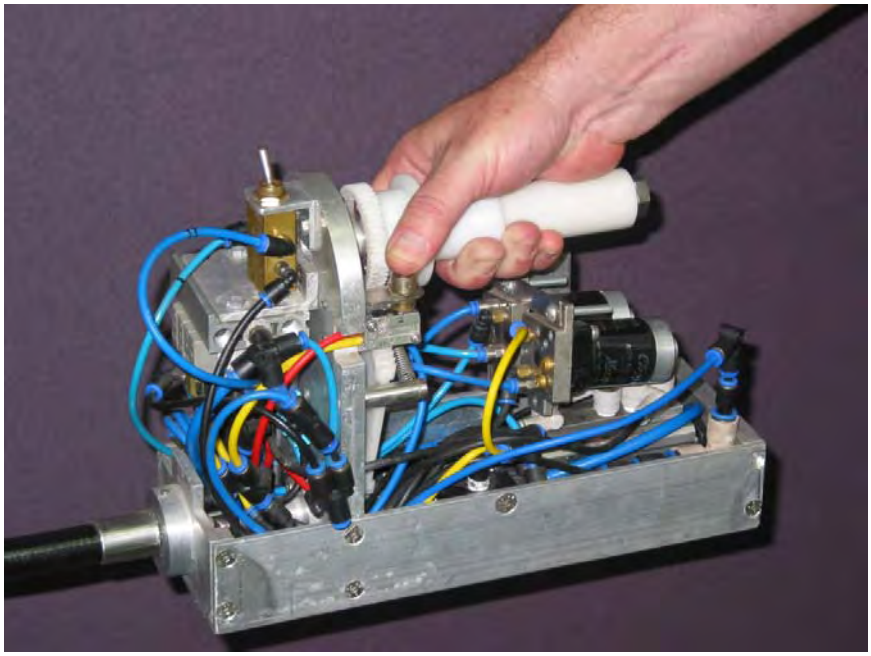

Figure 1 – Original Tool

Placing the plugs in the neck region requires a much simpler tool that is:

- More durable
- Lightweight
- Less expensive to manufacture
- Easier to clean

And:

- Produces a more reliable seal.
- Has a reduced cycle time

Plugging in the neck can result in a full oesophagus, the effects of which will be investigated in this part of the project.

It was decided that the most appropriate tool would be a stainless steel wand like arrangement with a pneumatic cylinder to actuate the plug. For the purpose of keeping the tool as light and compact as possible, it was decided that plug release would be achieved by the operator manually twisting the tool. The final prototype tool is shown in Figure 2.

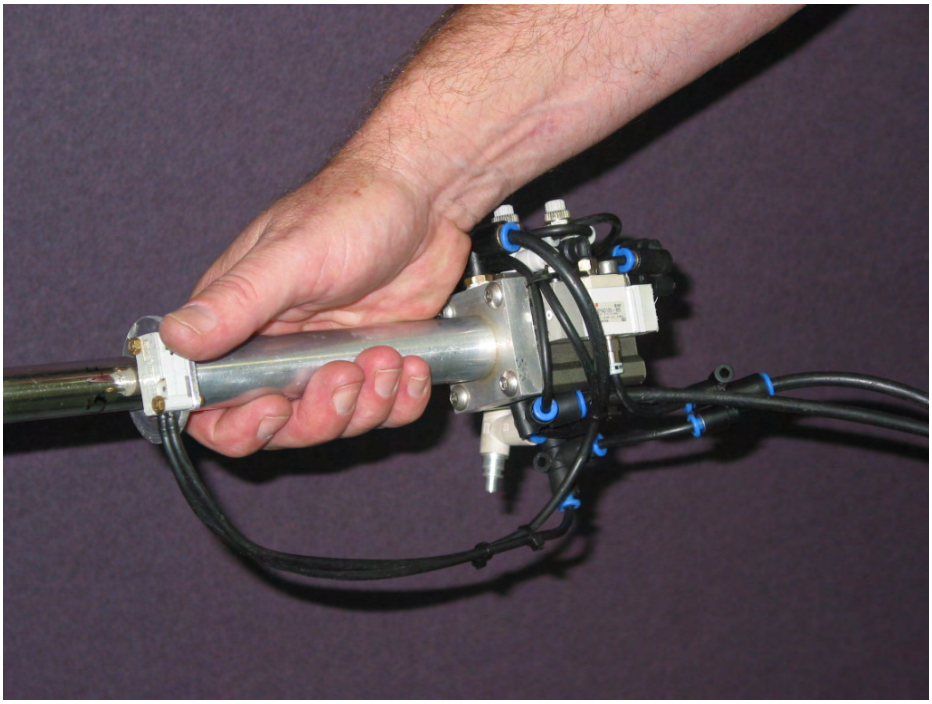

Figure 2 – Final Prototype Tool

Initial development and testing of the prototype plug applicator was carried out at Cannon Hill. The results of which are included in **APPENDIX A – TRIAL NOTES**.

As the final stage of this project, two separate works trials were conducted at Wallangarra abattoir. The results are included as Trial#12 and Trial#13 in **APPENDIX A – TRIAL NOTES**.

4. RESULTS & DISCUSSION

The results for Objective 2 of this project are based on the 2 works trials at Wallangarra. A full report of these are included as Trial#12 and Trial#13 in **APPENDIX A – TRIAL NOTES**.

From these trials it was found that the mouth-opening tool was able to successfully open the mouth in approximately 75% of attempts in Trial#12, and virtually all attempts in Trial#13. In the cases where the tool was unable to open the mouth, it was due to insufficient torque from the rotary actuator. As the tool has clearly demonstrated the mouth opening concept, it was decided that remanufacturing the existing tool for a more powerful actuator was not warranted.

The results from Objective 1 of this project (Trial#8) showed that resistance at the back of the head may be a problem, however, a high rate of success could be expected. Trial#8 was carried out using a piece of 20mm diameter tube to simulate plug insertion.

Trial#12 and Trial#13 did not produce the expected results. Considerable resistance was felt at the back of the neck. In Trial#13, only 13 of the 46 recorded attempts achieved insertion, and only 5 of these resulted in a correctly applied plug. The other 7 attempts resulted in the plug remaining attached to the tool when it was withdrawn. This is an indication that the plug was pushed out through the oesophagus and into the body. The issue of pushing out through the oesophagus did not show up in Trial#8 as the Halal cut and subsequent processing tend to remove the evidence.

Electric stunning not only has the result of clamping the mouth shut, but also tightens the muscles in the neck and pulls the chin down and back. This produces a severe bend at the back of the head (See Figure 3). This bend obstructs the successful insertion of the plug.

Figure 3

Attempts to straighten out the neck by bending the head back only resulted in the neck bending near the shoulders. The bend at the back of the head remained (See Figure 4).

Figure 4

Attempts to reduce the severity of the neck obstruction were made by trying different stunning positions on the head, and using a lower voltage. Neither of these options produced a detectable or significant improvement.

During Trial#12, 10 sheep were stunned using a captive bolt stunner. Some of these exhibited slight clenching of the jaws, but this was easily handled by the mouth opening tool. Plugging of the 10 sheep was straightforward, and all were processed through to evisceration without any leakage.

For trial#13, 21 sheep were stunned with the captive bolt stunner. The first 13 were stunned by Wallangarra staff. Of these 13 sheep, 11 were plugged successfully while the plug remained on the tool for the other 2. These 2 sheep exhibited similar jaw locking and muscle tension as electrically stunned sheep.

The slaughterman stunned the next 8 sheep, and plug insertion was quick and convenient at chain speed. All 8 resulted in a perfect seal. When correctly stunned, the mouth opener is not required (see Figure 5) and plugging can take place further back in the restraint, which eliminates the problem of the plugging tool hitting the chain. The hand normally used for the mouth opener is freed up for loading plugs, and positioning the head.

Figure 5

Initially during Trial#12 and Trial#13, the full oesophagus was cut during neck opening. Once the situation had been explained to the operator, the damage did not occur again.

It was observed that ingesta often leaked out of the severed oesophagus of unplugged sheep (see Figure 6) with sufficient quantity and frequency to wash a "clear" path in the blood on the floor under the chain. A correctly applied oesophagus plug completely eliminates this leakage.

Figure 6

5. CONCLUSIONS

The works trials at Wallangarra Abattoir have shown that the mouths of electrically stunned sheep can be reliably and consistently opened using the mouth opening tool concept developed during this project.

The trials have also shown that, in a works situation, it is highly unlikely that plugs can be consistently and reliably inserted into the oesophagus of sheep stunned with a conventional electric stunner. This is due to the muscle contraction in the neck region.

The limited trials with captive bolt stunning, due to Wallangarra being a Halal works, clearly showed the benefit of oesophagus plugging non-electric stunned sheep. The process is more convenient, faster and, if a suitable method of stunning is found, more readily integrated into existing plants.

Correctly applied oesophagus plugs provide an effective seal (see Figure 7). There is a zero tolerance on contamination from paunch contents, and the plugs provide a seal before any entry is made to the body cavity. They also prevent contamination of the blood during bleeding.

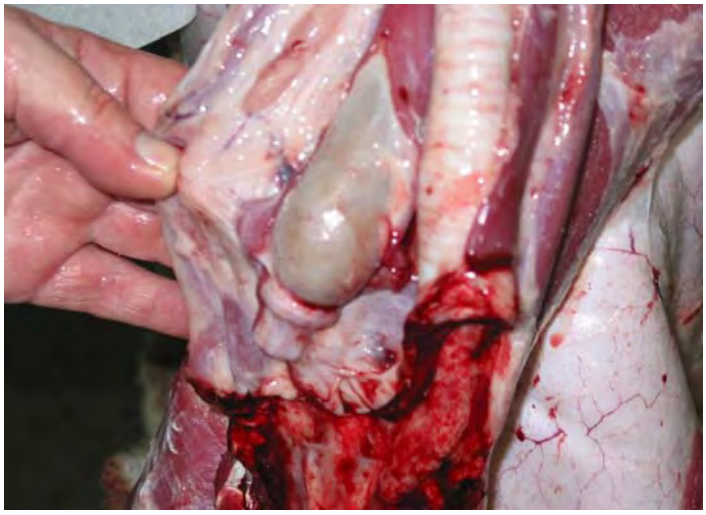

Figure 7

6. RECOMMENDATIONS

It is recommended that alternatives to conventional electric stunning be investigated.

Some possible options are penetrating bolt and mushroom head pneumatic stunners.

Technology being developed in an existing MLA project, PRTEC.013 Automating the Cattle Knocking Box by Using Electronic Stunning, may also be suitable for application in sheep stunning. One of the objectives of this project is to provide electric stunning without subsequent muscle activity.

APPENDIX A – TRIAL NOTES

105084 Sheep mouth opening trial#9

Date: 26-08-02

Aim: Trial the plug applicator.
Trial the idea of rotating the whole tool to release the plug.

Procedure: Captive bolt stun a sheep and use the mouth opener and plug applicator to apply one or more plugs to the neck of a ewe.

Results: Three plugs were applied to the neck. Release by rotating the tool worked well and felt natural for an operator.

All three plugs resulted in a complete seal with the oesophagus full above the top one. A knife was used to free the bottom 200mm of weasand and rodded with the inner section of a beef elastrator rodding tool. The full weasand did not appear to affect evisceration.

The liquid was milked up the weasand while rodding and the operator believed the plug could be used as a grip as long as this was done to prevent hydraulic pressure dislodging the plug by tearing the weasand.

Conclusions: Releasing the plug by rotating the whole tool appears to work on non electrically stunned sheep. This results in a light simple tool but has to be tested on electrically stunned sheep to see if the weasand grips the tool and rotates with it.

Actions: Repeat trial with electrically stunned sheep.
Try clearing the start of the weasand by tearing in the usual way.

105084 Sheep mouth opening trial#10

Date: 16-09-02

Aim: Trial the mouth opener, applicator and rodding tool combination on an electrically stunned ewe.

Procedure: Electrically stun a sheep and use the mouth opener and plug applicator to apply one or more plugs to the neck of a ewe. Use the new rodding tool.

Observations: The first attempt to plug failed with the plug coming out in a wad of grass. The sheep had been eating right up to the point of being brought in.
Two more plugs were applied at a shorter insertion distance. Both felt as though they worked correctly.
Results: The first plug failed but the other two produced a perfect seal. The operator cut the weasand as he opened the neck but the plugs had sealed up to that point. Rodding with the new tool worked well.

Conclusions: The mouth opening, plugging and rodding combination seem to work with electrically stunned sheep.

Actions: Repeat trial.

105084 Sheep mouth opening trial#11

Date: 16-09-02

Aim: Trial the mouth opener, applicator and rodding tool combination on an electrically stunned ewe.

Procedure: Electrically stun a sheep and use the mouth opener and plug applicator to apply one or more plugs to the neck of a ewe. Use the new rodding tool.

Observations: Considerable resistance was felt inserting the first plug. Two more plugs were applied.

Results: All three plugs were found out in the body.

Conclusions: The first application resulted in the weasand being damaged and the plugs being pushed out into the body. This is the first time we have observed this occurring with sheep. The damage may have been caused by "operator error" as trialling only a few sheep at Cannon Hill does not allow the operator to develop feel and a rhythm for the task. As the plugging system appears to be mechanically functioning, very little can be gained by further trials at Cannon Hill.

Actions: Undertake works trials.

105084 Sheep mouth opening trial#12

Date: 24-09-02

Aim:

1. Undertake works trials of mouth opener, plug applicator and rodding tool at Wallangarra abattoir.
2. Evaluate the effectiveness of the plugs.

Procedure: Apply the plugs immediately after stunning. Batches of approximately 5 will be applied and followed through to evisceration to observe their effectiveness.

Observations: Wallangarra provided a much better stand to work from than in earlier trials. This allowed a convenient work position to be achieved.

We commenced the trial by using just the mouth opener. Initial attempts to open the mouths were unsuccessful. From previous trials, we are aware that the torque produced by the rotary actuator on the existing tool is marginal. After some experimentation, we were able to achieve a success rate of approximately 75% and decided to proceed with the rest of the trial.

Initial attempts to plug were completely unsuccessful. The plug applicator is the same length as the simulated tool used in previous trials but does have a pneumatic cylinder, hoses and valves attached to the end. It was found that these kept hitting the overhead rail, and on occasions caught on the chain.

Once we were able to achieve mouth opening, we found that entry to the oesophagus was blocked at the back of the mouth. With one person holding the head and the other inserting the tool, we were able to gain entry to the oesophagus in about 50% of attempts. To do this required considerable force, and in some cases severe damage was done to the oesophagus at the back of the head.

In an attempt to ascertain if the resistance to insertion is caused by the shape of the plug and applicator, we reverted to trialing the simulated tool. It was found that insertion was slightly easier, but still far from the results achieved in previous trials. This tool is lighter, more manoeuvrable and has a slightly more rounded end than the plug and applicator combination. These differences account for the slight improvement, but do not explain the extreme resistance to insertion when using the applicator and plug.

For the next part of the trial we used the original hand operated mouth opening blade. In earlier trials it was found that this tool could be used one handed to open mouths. During this trial, it was found that most of the approximately 30 sheep processed required far more force to open the mouth than in previous trials. Many of them required the operator to use two hands and were still difficult. We also varied the position of the stun but found no correlation between stun position and amount of lockjaw.

Sheep that appeared to be successfully plugged were followed through the plant. Initially we found that the oesophagus was occasionally cut above the plug. This was brought to the attention of Wallangarra staff and a simple change to procedure solved

the problem. Rodding with our tool worked well. For simplicity, Wallangarra staff continued to rod in their usual way with plastic clips.

Three batches of five electrically stunned sheep were then plugged and followed through the plant with the results below.

Ten sheep were then stunned with a captive bolt and plugged. Even these sheep exhibited some lockjaw after stunning. This has not been observed in previous trials. The mouth opener easily handled this and plugging was straight forward.

It was noticed that the plugged sheep showed no sign of ingesta contamination in the neck region, while unplugged sheep often showed such contamination and require further trimming.

Chain speed was 350/hour.

Results: Of the 15 electrically stunned sheep plugged in batches of 5 near the end of the trial, 12 were successful and 3 failed due to damage to the oesophagus caused by the excessive force required to insert the plug.

All 10 captive bolt stunned sheep were successfully plugged.

Throughout the duration of this trial, it is estimated that approximately 100 attempts were made to insert the plugging tool or simulated plugging tool, with approximately a 50% success rate at gaining entry to the oesophagus.

Conclusions: The sheep used in this trial exhibited far more lockjaw and throat closure than has been observed in previous trials.

The mouth opener clearly requires more torque, but this should only be a mechanical design issue.

It was difficult to maintain cycle time with the effort required to gain entry to the oesophagus of electrically stunned sheep.

When successful entry has been gained, the results are excellent with a visual reduction in contamination.

Use of the internal oesophageal plug appears to be compatible with rodding and evisceration.

The manager at Wallangarra suggested that alternative methods of stunning may be a way realizing the benefits of plugging without the problems of electrical stunning.

Actions: Report to Sean Starling

105084 Sheep mouth opening trial#13

Date: 22-10-02

Introduction: The previous trial at Wallangarra on 24-09-02 resulted in successful insertion in approximately 50% of attempts, which is well below the results of previous trials. It is thought that the ability to insert is marginal and that factors such as stress due to the drought may cause greater tension in the muscles in the neck around the oesophagus. In an attempt to allow for such factors, this trial has been delayed for approximately one month.

The plug applicator has been shortened by 130mm in an attempt to stop it fouling the chain and to make insertion more controlled and quicker.

Aim:

3. Undertake works trials of mouth opener, plug applicator and rodding tool at Wallangarra abattoir.
4. Evaluate the effectiveness of the plugs.

Procedure: Apply the plugs immediately after stunning. Batches of approximately 5 will be applied and followed through to evisceration to observe their effectiveness.

Observations: The work platform was raised another 300mm which has made insertion easier.

The trial was commenced using just the mouth opener. It was noticed that this was more successful than the previous trial.

As in the previous trial, insertion was possible in approximately 50% of attempts. Even when insertion occurred, the plug often remained on the tool after withdrawal. The most likely explanation for this that the plug was pushed out through the wall of the oesophagus.

It was observed that the electric stunning has the effect of pulling the chin down and bending the neck at the back of the head. Attempts to straighten out this bend just resulted in the neck bending back closer to the shoulders.

The stunner voltage was lowered from 300 volts to 250 volts with no appreciable improvements. As with the previous trial, stunner placement seemed to have no effect.

Attempts to insert at different angles also failed to achieve a better result. The original hand operated blade tool was trialed as it has a larger opening and allows the plug applicator to be inserted at a better angle. This did not provide any improvement.

To test the plugs, 21 sheep were stunned with a captive bolt stunner. The first 13 were stunned by Wallangarra staff. Of the 13 sheep, 11 were plugged successfully while the plug remained on the tool for the other 2. These 2 sheep exhibited similar jaw locking and muscle tension as electrically stunned sheep.

The slaughterman stunned the next 8 sheep, and plug insertion was quick and convenient at chain speed. All 8 resulted in a perfect seal.

On some occasions, the full oesophagus was cut during neck opening. Once the person performing this task was notified, there was no problem. The operator indicated that this would not be a problem if the plugs are in general use.

As in the previous trial, the plugs appeared to be compatible with existing rodding and evisceration processes.

We investigated the duration of the effects of electric stunning by determining how long after stunning the mouth could be opened by hand. Typically this could be achieved between 12 – 40 seconds.

It was observed that ingesta often leaked out of the severed oesophagus of unplugged sheep with sufficient quantity and frequency to wash a “clear” path in the blood on the floor under the chain

Chain speed was 350/hour.

Results: Of the 46 recorded attempts to insert a plug into electrically stunned sheep, 33 failed, 13 achieved insertion and 5 resulted in a seal.

Of the 21 attempts on sheep stunned with a captive bolt 2 failed due to what appears to be a badly placed stun.

Conclusions: The muscle contraction in the neck, due to electric stunning, makes consistent insertion of oesophageal plugs unlikely. The distortion of the neck and force required result in either the inability to insert, or severe damage to the oesophagus and the plugs being pushed out into the body.

As the mouth opening tool was able to succeed on most attempts, the muscle contraction caused by stunning was slightly less than the previous trial.

Used with captive bolt stunning, the plugs can be applied quickly and easily. They provide a reliable seal that is compatible with subsequent processing.

From observation, there is a significant problem with ingesta leakage, and the oesophagus plugs are effective in dealing with it.

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC

CSIRO AFISC Australian Food Industry Science Centre

Sheep Jaw Opening System – PRTEC.006

Objective 1 Report

AMPC

MEAT & LIVESTOCK AUSTRALIA

Prepared for: Meat & Livestock Association
Australian Meat Processor Corporation Ltd

Prepared by: Jeff Owen, Researcher

Date: 26th April 2002

EXECUTIVE SUMMARY

The project, Sheep Jaw Opening System – PRTEC.006 consists of 2 parts, as follows:

1. Develop a method and equipment to open the mouth of electrically stunned sheep to allow the insertion of an oesophagus sealing plug.
2. Conduct and evaluate plugging trials with the original AMT plugger. This piece of equipment will require extensive remanufacture or replacement before trials can be conducted.

The first part of this project has been completed, culminating in a works trial of the prototype tool at the Southern Queensland Exporters plant (Wallangarra Abattoir).

During this trial, 85 attempts were made to open the mouths of electrically stunned sheep. Of these, 81 were successful. A simple modification to the tool eliminated the cause of 3 of the failures, and the 4th failure requires the tool to be more powerful.

The plugging process was simulated by inserting a 20mm diameter rod into the neck region of the oesophagus. An inexperienced operator was easily able to carry out this operation at the chain speed of 372 sheep / hour. With optimisation of the process, considerably faster throughput should be possible.

The weasand clips currently being used at Wallangarra cost approximately 5 cents each. In the plugging process, the clips are replaced by plugs costing a predicted 3 – 5 cents each. Use of the plugs should also result in reduced contamination.

The Plant Manager of Wallangarra Abattoir has indicated support for the continuation of this project and that manning and distribution of tasks would be best handled by the works.

Table Of Contents

Table of Figures

1. INTRODUCTION

In 1997 Australian Meat Technology Pty Ltd (**AMT**) engaged CSIRO Food Science and Technology (now trading as Food Science Australia) to develop an internal oesophagus sealing system for sheep. CSIRO and AMT had previously developed an internal beef oesophagus sealing system (**Plugging**) and this technology was modified and scaled down to suit sheep.

As with the beef plugging, this project was intended to provide an improved method of oesophagus sealing without the risk of contamination associated with entering the body through the hide.

This previous project resulted in a suitable plug design and applicator, which was successfully tested at the CSIRO Cannon Hill slaughter floor. A single cavity plastic injection die was manufactured to allow a larger number of plugs to be produced for works trials. At this point, the CSIRO involvement in the project concluded.

For humane reasons, most trials at Cannon Hill were carried out using a captive bolt stunner to avoid the possibility of animals recovering during trials. Lockjaw of electrically stunned animals had been identified as a possible problem and a simple tool was manufactured to force the mouth open (*Figure 1*). Several electrically stunned sheep were successfully plugged using this tool. While this tool can be used to open the mouth, it is too slow and awkward for use in an abattoir.

Electrically stunned sheep can tilt their head down and pull the head back towards the body. This reaction results in the oesophagus assuming a severe "S" bend with changes of direction just past the mouth and at the entry to the thoracic cavity. AMT staff indicated that they would address the lockjaw issue during more extensive works trials.

Lockjaw and muscle contraction issues were not resolved before AMT ceased to trade.

2. PROJECT OBJECTIVES

Objective 1. (The basis of this report)
Develop a proof of concept prototype device for opening the jaws of electrically stunned sheep, and demonstrate the ability to then insert an oesophageal plug into the neck.
This device will preferably have the following features and capabilities:

- Hand held
- Suitable for trials at the Food Science Australia Cannon Hill slaughter floor
- Suitable for limited works trials
- Allow one person to open the jaw and apply the plug
- Be compatible with existing processing facilities
- Operate at line speed or at least demonstrate the potential to do so

Objective 2 (Not yet undertaken)
Produce a suitable plugging tool and undertake works trials.

3. METHODOLOGY

The original AMT / CSIRO project determined that it was possible to open the mouth of electrically stunned sheep by pushing a blade through the mouth from the side and rotating it to force the jaws apart (*Figure 1*). It was found that considerable force is needed to open the mouth and that any practical tool would have to be powered. The tool is required to be lightweight and compact, thus easily manoeuvrable, to be able to achieve sheep abattoir cycle times. The tool also has to perform the function of a "handle", allowing the operator to reposition and hold the head while inserting the plug.

Figure 1 – AMT tool

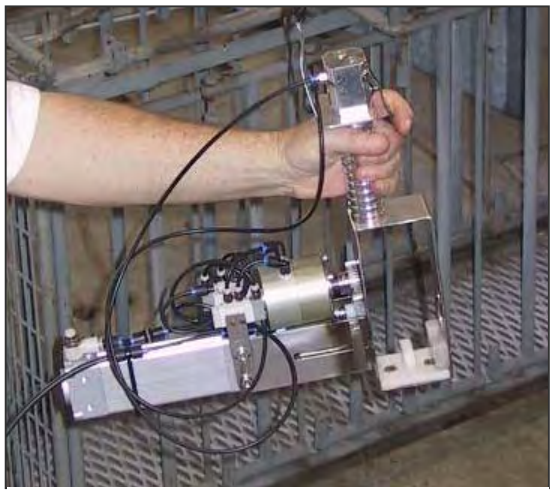

Figure 2 – Prototype Mouth Opening tool

It was decided that the most appropriate form of tool would be a pneumatically powered, muzzle like arrangement with a handle on top. Basic dimensions for the tool were determined by measuring sheep heads and a prototype designed and manufactured. (*Figure 2*)

Testing and development of the prototype was carried out at Cannon Hill. A report of each of these trials is included in Appendix A. As the final step of this stage (Objective 1), a works trial was conducted at Wallangarra abattoir. The results are included below and a report is included in Appendix A.

For the purposes of Objective 1 of this project, the application of an oesophageal plug was simulated by inserting a 20mm diameter tube.

Where practical, the works trial at Wallangarra was video taped and later analysed for the results shown below and in Appendix A. Not all of this trial was video taped due to the cramped work area and the spectators who came to watch the process. The following results are based only on the video taped part of the trial.

4. RESULTS & DISCUSSION

The results for Objective 1 of this project are based on the works trial at Wallangarra. A full report of this trial is included in Appendix A.

In total, 85 sheep were recorded being processed. Of these, the mouth was opened in 81 cases. Of the 4 failures, 3 appear to have been caused by the bottom jaw block, and the fourth due to the rotary actuator having insufficient torque. In a few cases, the actuator struggled to open the mouth but was successful.

With the jaw block removed, 56 sheep were processed with the mouth failing to open due to insufficient torque in one case (see above). A second failure occurred when the head slipped in the tool.

Of the 36 attempts to insert the simulated plugger (*Figure 3*), 7 failed. One when the head slipped, 4 due to the work platform being too low and can be discounted, and 2 due to tightness at the back of the mouth.

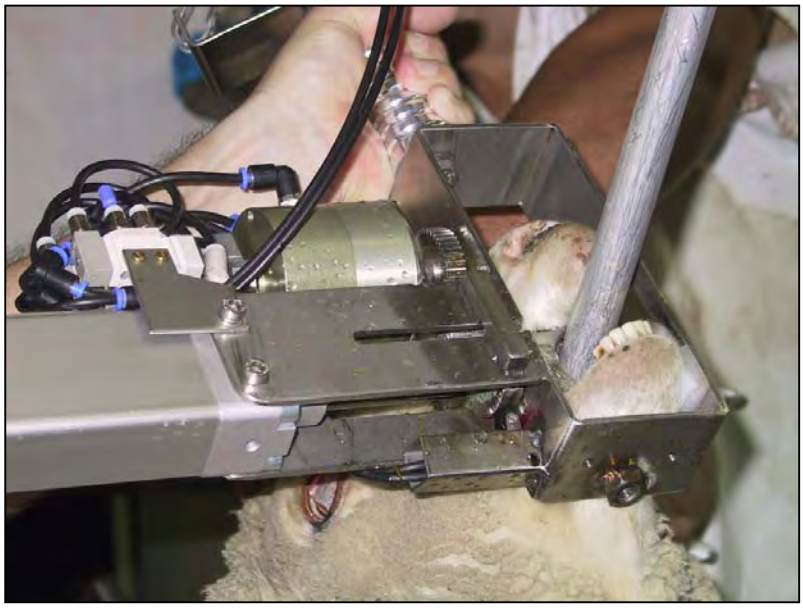

Figure 3 – Mouth Opening and simulated plugging

The single incident of the head slipping in the tool occurred after the bottom jaw block was removed. The purpose of this block is to prevent such slippage. With only 1 incident in 56 operations with the block removed, a much less aggressive design could be used that does not risk jamming the bottom jaw, but provides more security.

Tightness at the back of the mouth was experienced on a number of occasions but was easily pushed through. On 2 occasions, the insertion was aborted due to a higher than normal resistance. It is believed that insertion will be possible with more experience and a stable work platform.

The chain speed at the time of the trial was 372 animals / hour. Even with an inexperienced operator, the simulated plugging process was easily performed at this rate.

The insertion of an oesophageal plug replaces the usual weasand clip, which weighs 2.7 grams and costs approximately 5 cents each on quantities of 10,000. The plug weighs 1.6 grams and is expected to cost 3 – 5 cents each.

In discussions after the trial, the manager of Wallangarra abattoir indicated support for the process. He also indicated that manning and distribution of tasks would be best handled by the works and that they would make it work.

5. CONCLUSIONS

The works trial at Wallangarra Abattoir has shown that the mouth of electrically stunned sheep can be reliably and consistently opened for plug insertion. With the bottom block removed, the existing tool is suitable for the task, but could be improved with features such as a spring-loaded plunger or even simple serrations to replace the bottom block.

On a few occasions, the tool struggled to open the mouth. This could be improved with a more powerful rotary actuator or, as suggested by Wallangarra staff, investigate the effect of stunner placement to reduce the clamping of the jaw.

As far as can be ascertained by simulated plugging, the process can easily be carried out at a chain speed of 372 animals / hour. Works trials with real plugs are needed to determine the true cycle time of this process.

In the case of 2 sheep, the insertion was aborted due to the resistance felt at the back of the mouth. Several other sheep exhibited significant resistance but the simulated plugger was pushed through into the oesophagus. Trials with actual plugs need be undertaken to determine if, and to what extent, the constriction is a problem. A more secure work platform would aid the process.

6. RECOMMENDATIONS

It is recommended that this project proceed to Objective 2 as follows:

1. Remanufacture the existing AMT plugger to insert plugs into the neck region. If this is not practical, design and build a new tool.
2. Obtain plugs from the existing AMT die held by Queensland Plastics Moulding Co. Pty. Ltd.
3. Trial the mouth opening tool, plugger and plugs at Food Science Australia Cannon Hill.
4. Conduct works trials at Wallangarra Abattoir.
5. Evaluate the tools, plugs and process.
6. Prepare and submit the final report.

APPENDIX A – TRIAL NOTES

105084 Sheep mouth opening trial #1

Date: 30-1-02

Aim: To trial the mouth opening device for the first time.

Procedure: Captive bolt stun a lamb and use the device to open the mouth.

Observations:
The device was used to open the mouth a number of times from the right hand side of the lamb. It was observed that the RH cheek was pushed/dragged across the opening of the mouth.

On some occasions, the blade pierced one or both of the cheeks. The tongue became severely damaged by the guillotine action of the blade entering the location slot on the far side of the frame.

When the cheek did not obstruct the mouth, it was found that a 20mm pipe could be inserted into the throat.

The width of the frame appears excessive and on occasions, the lower jaw was pushed off the bottom location block.

The location block generally appeared to function well, particularly after modifications were carried out.

Once applied, the device provided a secure handle for positioning and controlling the head.

Conclusions: The head restraint and control functions of the device worked well. Narrowing the frame by 10 – 12mm should improve the location of the head.

Damage to the tongue should be eliminated by opening up the location hole on the far side of the frame to prevent the guillotine action.

The cheek being dragged across the mouth opening may be reduced by the muscles tightening up when electrical stunning is used. Increasing the blade width may also tighten up the skin and reduce mobility.

Actions: "Pack" the far side of the frame to reduce the overall width. A 10 - 15mm reduction appears to be appropriate.

Increase the blade width from 36mm to 50mm.

Enlarge the hole where the blade penetrates the far side of the frame.

Trial with electrical stunning.

105084 Sheep mouth opening trial #2

Date: 5-2-02

Aim: Trial modified mouth opener.

The modifications are a 13mm packer on the far side, increasing the blade width from 36mm to 50mm and enlarging the hole in the far side to prevent tongue damage.

Electrical stunning will be used to try and tighten the cheeks.

Procedure: Electrically stun a lamb and quickly try the mouth opener. For humane reasons, stun with a captive bolt to carry out more tests and observations.

Observations:
With electrical stunning and wider blade, there appeared to be a slight reduction in the amount of cheek pulled into the mouth.

The packer block on the far side improved the location of the jaw.

The larger hole for the blade prevented the tongue damage evident in trial #1.

Several successful attempts were made to insert a simulated plugging device when the cheek was not obstructing the mouth. This was carried out after the effects of the electric stun may have worn off. The wider blade provided much better access to the mouth for this operation.

The chin block functioned well and the head was securely held. Even vigorous shaking did not dislodge the head.

To address the cheek problem, a 50mm wide blade was inserted flat, then rotated to open the mouth. This arrangement was tried as part of the original AMT project and works well apart from the tendency for the blade to slip out the front of the mouth.

Conclusions: Apart from the cheek problem, the concept works well. Combining the location and handling function of the existing tool with the rotating blade concept is the next logical arrangement. The down side of this concept is that the increased complexity will increase the mass of the tool and may increase the cycle time.

Actions: Modify the tool to allow the blade to be inserted horizontally then rotated. The rotation will be performed manually to test the theory before undertaking the substantial modifications required to automate this procedure.

105084 Sheep mouth opening trial #3

Date: 8-2-02

Aim: Trial modified mouth opener.

The tool has been modified to insert the blade horizontally. Once inserted, the blade is rotated manually using a shifter. This arrangement allows the testing of the concept without making extensive modifications to the tool.

Procedure: Electrically stun a lamb and quickly try the mouth opener. For humane reasons, stun with a captive bolt to carry out more tests and observations.

Observations:
The blade enters the mouth easily and without the requirement for careful placement. Rotating the blade required considerable force, particularly when rotating the front edge up. Rotating the other way required less force but may be less stable. The tongue protruded through the hole but did not hinder insertion of a simulated plug.

The chin blocks provided secure location of the head that could not be dislodged with severe shaking.

Examination of the mouth after head removal revealed a cut or tear across the top of the tongue. The cause of this is not apparent. Rotating the front of the blade up may drag the tongue forward causing the damage.

Inserting the simulated plugging tool was straightforward and the blade width and hole size were suitable.

Conclusions: This trial showed that the insert then rotate arrangement may work. It would be necessary to modify the tool and carry out more extensive trials to determine if it is a reliable process.

Actions: Modify the tool to automate the process.

105084 Sheep mouth opening trial #4

Date: 21-2-02

Aim: Trial modified mouth opener.

The tool has been modified to insert the blade horizontally, then automatically rotate the blade.

Procedure: Electrically stun a lamb and quickly try the mouth opener. For humane reasons, stun with a captive bolt to carry out more tests and observations.

Observations:
The blade enters the mouth easily and without the requirement for careful placement. Tongue and cheek were observed protruding out of the clearance hole in the far side of the frame. The blade was unable to rotate. At the time, the hypothesis was that the tongue and cheek prevented rotation, but subsequent viewing of the video showed that the bottom jaw failed to engage the bottom location block. Three attempts were made under electrical stunning with similar results.

The lamb was then stunned with a captive bolt. By this time, the lockjaw effect had worn off. The tool successfully opened the mouth 4 times in a row. Even though the tongue was still pushed across, insertion of a simulated plugging tool was easy and straight forward. Further trials resulted in some good results and some where the blade pushed the far cheek out into the frame. When this happened, the top jaw was pushed sideways and distorted the head.

The clearance hole in the far side of the frame was enlarged and a second lamb was stunned (no video). Similar results to the first animal were noted. A 12mm piece of wood was inserted to prevent the top jaw being pushed sideways. This seemed to produce an improved result.

Conclusions: Greater torque is required. The blade and frame design need more refinement. Future trialing should be carried out at Wallangarra to access a greater number of electrically stunned animals.

105084 Sheep mouth opening trial #5

Date: 14-03-02

Aim: Trial modified mouth opener at Wallangarra Abattoir.

The tool has been modified to include a two vane rotary actuator.

Procedure: Install the tool at Wallangarra and trial.

Observations:
The tool was suspended by a spring balance above the "V" restraint. The first animal trialed resulted in the blade jamming partially rotated. To minimize disruption and to allow the animal to be stuck before recovery, the tool was violently pulled out of the mouth. Subsequent trials resulted in a similar result. It was observed that the small idler gear had stripped.

The original handheld blade device was trialed and found to consistently open mouths. The torque required varied from very little to considerable effort using one hand.

It may be possible for the stunner operator to pull the head back for mouth opening. This will speed up the process and may allow the blade to be positioned by sight.

The current hand tool was then applied, without operation, to observe positioning.

It was noticed that if the blade stalls when extending, the back pressure sensor prematurely rotates the blade.

Conclusions: It is unclear whether the damage to the gear occurred in the first application and caused the failure or was as a result of the force needed to remove the tool.

The rotary actuator has more than sufficient torque and should be able to rotate. The possible reasons it cannot rotate are:

- The gear was damaged
- The jaw bottoms out on the block and/or peg
- It rotates prematurely while still in the frame

Positioning the tool is not consistent and it may require the head to be held by the person doing the stunning. This will allow a faster cycle time. The tip of the blade should be extended and asymmetrical to allow visual alignment and entry further forward.

Actions: The backpressure sensor should be replaced with a limit switch.

105084 Sheep mouth opening trial #6

Date: 03-04-02

Aim: Trial modified mouth opener at Cannon Hill.

The tool has been modified as follows

- Blade length increased
- Blade tip biased towards the front
- Limit switches instead of the back pressure sensor
- Plastic idler replaced with aluminium

Procedure: Trial at Cannon Hill with the tool suspended by a spring balance, and the sheep held in a "V" restraint. Slaughterman to stun the sheep then pull the head back into position.

Observations:
Sheep # 1 (Ewe)
The sheep was electrically stunned, the head pulled back and the tool was applied successfully. This resulting in the mouth being opened and the simulated plugger easily inserted.

For humane reasons, the sheep was stunned with a captive bolt stunner and 2 more successful attempts were made. Slight damage to the inside of bottom jaw was observed. The slaughterman indicated, that in his opinion, this was acceptable. Vigorous shaking did not dislodge the captured head. However, it was noted that there was no movement of the head in the tool as was experienced when used on lambs.

Sheep # 2 (Ewe)
The first attempt worked very well and the simulated plugger was easily inserted. While the sheep was stilled stunned, two more attempts were quickly made. In both cases, the blade extended correctly but failed to fully rotate. The sheep was stunned again and two more attempts were made with similar results. It was noted that the top lip had been pierced and a captive bolt stunner was used. Several more attempts were successful.

Conclusions: The results of this trial indicate that the difficulties experienced at Wallangarra Abattoir were caused by the back pressure sensor. Changing to limit switches and a longer metal idler gear seem to have corrected the problems. The inconsistent results with the second sheep may have been caused by insufficient clearance between the blade and the bottom jaw block.

Actions: Provide more room for the bottom jaw. This could include replacing the block with a pin. Trial at Cannon Hill.

105084 Sheep mouth opening trial #7

Date: 08-04-02

Aim: Trial modified mouth opener at Cannon Hill.

The tool has been modified as follows

- Side location block reduced in thickness by 3mm
- Bottom plastic block reduced in thickness by 3mm
- Jaw block rounded off more
- Provision for the bottom block to be replaced with a bolt to provide an adjustable jaw location pin

Procedure: Trial at Cannon Hill with the tool suspended by a spring balance, and the sheep held in a "V" restraint. Slaughterman to stun the sheep then pull the head back into position.

The stunner to be set at 400V.

Observations:
Sheep # 1 (Ewe)
The sheep was electrically stunned and the tool successfully opened the mouth.

Insertion of the simulated plugger met with considerable resistance at the back of the mouth and the procedure was aborted.

The sheep was stunned with a captive bolt and 2 successful insertions were made.

Sheep # 2 (Ewe)
The sheep was electrically stunned, the mouth opened and the simulated plugger inserted. This procedure was successfully repeated.

Sheep # 3 (Ewe)
Two attempts at opening, after an electric stun, failed. The jaw appeared to sit on top of the bottom location block.

The sheep was stunned with a captive bolt and 4 successful attempts were made. It was observed that the jaw appeared to "pop" down over the block, suggesting the block is too thick for the gap between the jaw bones.

Sheep # 4 (Ewe)
The first attempt to open the mouth after an electric stun was successful. A further 2 attempts were unsuccessful with the jaw appearing to sit on top of the block.

Conclusions: Mechanically, the mouth opening tool is working correctly.

When the operation is unsuccessful, it appears to be caused by the jaw becoming jammed between the blade and the location block.

Actions: Go to Wallangarra Abattoir and try the mouth opener on a greater number of animals. The inconsistent results may be a result of operator error and trialing a larger number of sheep may allow an appropriate technique to be developed.

Trialing with the bottom block removed should determine if the jaw is being jammed on this item. There is some concern that removing this feature will allow the head to slide out of the tool. If this occurs, the adjustable bolt can be fitted and trialed. This would best be done at Wallangarra.

105084 Sheep mouth opening trial #8 – Wallangarra Abattoir

Date: 09-04-02

Aim: Trial the mouth opening tool at Wallangarra Abattoir. The jaw location block has been modified since Trial #7. The top of the block has been made more "pointed" in an attempt to stop the bottom jaw sitting on top of it. We will also trial the tool with the block removed to determine if it is the location block that is causing the inconsistent results. If removal of the block results in the head not being held securely enough, the adjustable bolt will be fitted and tested.

If the tool consistently opens the mouths, we will use the simulated plugging tool to determine if the plugging operation can be carried out at sufficient speed to suit Wallangarra Abattoir.

Procedure: Install and trial the mouth opening tool to develop a suitable operator technique. Test and modify the tool as required. Once suitable operation is achieved, process enough sheep to determine if the plugging process has a reasonable chance of being carried out at an abattoir such as Wallangarra.

Where practical, the trial will be video taped for later analysis.

Note: Not all of this trial was video taped due to the cramped work area and the spectators who came to watch the process. The following results are based only on that part of the trial that was video taped.

Observations:
Initially the mouth opening tool was tested with the bottom jaw block in place, and the simulated plugger was not used. The stunner operator was able to easily pull the head back with his free hand, or in some cases, with the embedded stunner.

Positioning the mouth opening tool was quick and straightforward with the extended blade providing an effective visual reference that was easily lined up with the mouth. It was noted that, after processing only a few sheep, operation of the tool became quick and easy.

At this point in the trial, we made no effort to process every animal as we did not want to inconvenience Wallangarra by potentially leaving gaps on the rail. It was noted that the positioning of sheep in the restraint was inconsistent. On some occasions there were large gaps between sheep, while at other times they were close together or even partially on top of each other. On one occasion a sheep going through backwards was observed.

With the bottom jaw block in place, and no simulated plugger, we processed 24 animals. Of these, the mouth was opened successfully on 21 of them. Subsequent examination of the video showed that in the 3 failed attempts, the bottom jaw appeared to be pushed sideways and was caught on top of the block.

The mouth opener and simulated plugger were then used together. It was found that the platform was too low to for effective insertion. Five attempts were made with the mouth being opened successfully in 4 cases and unsuccessful in 1 case.

The bottom jaw block was removed and the tool tested on 26 sheep without using the simulated plugger. Positioning the tool presented no problems and it felt as though the mouths opened easier without the constraint of the block. On one occasion, the blade stalled while rotating. A quick shake of the tool helped complete the rotation. The head felt secure in the tool, but not as reassuring as when the jaw block was used.

An upturned plastic box was added to the work platform to gain more height for simulated plugging. This resulted in a much better work position but was not the most secure of platforms as the box was flexible and slippery.

The mouth opener and simulated plugger were tested on 19 sheep of which 16 were processed successfully. Of the 3 failed attempts, 1 was aborted when the head slipped in the tool, a second failed when the tool simply did not have enough torque to overcome the clenched jaw and the third one resulted in the mouth being opened but resistance at the back of the mouth prevented entry to the oesophagus. Past experience suggests that greater force would have achieved insertion, but we did not want to risk damaging the sheep.

Nine consecutive sheep were processed to determine if we could keep up with the Wallangarra chain. In 8 cases, the mouth was opened and the simulated plugger inserted. The mouth was opened on the ninth sheep but resistance at the back of the mouth prevented insertion. The process was easily able to keep up with the chain which, according to Wallangarra, was operating at 372 sheep / hour. After a short break, another 5 sheep were successfully processed.

The damage to the mouth, which was evident in trials at Cannon Hill, did not appear at Wallangarra, suggesting the damage was caused by the bottom jaw block.

Results: In all, we recorded 85 sheep being processed. Of these, the mouth was opened in 81 cases. Of the 4 failures, 3 appear to have been caused by the bottom jaw block, and the fourth due to the rotary actuator having insufficient torque. In a few cases, the actuator struggled to open the mouth but was successful.

With the jaw block removed, 56 sheep were processed with the mouth failing to open due to insufficient torque in one case. A second failure occurred when the head slipped in the tool.

Of the 36 attempts to insert the simulated plugger, 7 failed. One when the head slipped, 4 due to the platform being too low and 2 due to tightness at the back of the mouth.

Conclusions: This trial has shown that the mouth of electrically stunned sheep can be reliably and consistently opened for plug insertion. With the bottom block removed, the tool is suitable for the task, but could be improved with features such as a spring-loaded plunger or even simple serrations to replace the bottom block.

On occasions, the tool struggled to open the mouth. This could be improved with a more powerful rotary actuator or, as suggested by Wallangarra staff, investigate the effect of stunner placement to reduce the clamping of the jaw.

As far as can be ascertained by simulated plugging, the process can easily be carried out at a chain speed of 372 animals / hour. Works trials with real plugs are needed to determine the true cycle time of this process.

In the case of 2 sheep, the insertion was aborted due to the resistance felt at the back of the mouth. Several other sheep exhibited significant resistance but the simulated plugger was pushed through into the oesophagus. Trials need to be undertaken with actual plugs to determine if, and to what extent, the constriction is. A more secure work platform would assist in carrying out the process.

In discussions after the trial, the manager of Wallangarra abattoir indicated support for the process. He also indicated that manning and distribution of tasks would be best handled by the works and that they would make it work.

APPENDIX B – TRIAL PHOTOS

Figure 4 - Mouth opened

Figure 5 - Apply simulated plugger

Figure 6 - Insert simulated plugger

Figure 7 - Simulated plugger fully inserted into neck