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# Bladestop Enhancements – Phase 5

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# Abstract

Project P.PIP.0260 Phase 4 Commercial Trials proved BladeStop could run under production conditions but also highlighted a need to redesign to improve operator interaction, robustness and reduce the complexity of the saw. This Project P.PSH.0618 addressed these issues by adopting an alternative mechanism utilising a pneumatic setup and high pressure air to clamp the blade. This approach resulted in a significantly simpler mechanism which addressed the projects objectives and reduced the complexity and potential areas of failure.
As a result of this the three saws have been successfully retrofitted, retested, reinstalled and recommissioned on all three processor sites these being Australian Country Choice, Gundagai Meat processors and Northern Coop Meat Company.

# Executive Summary

Project P.PIP.0260, Bladestop Phase 4 Commercial Trials, saw three Prototype BladeStop systems manufactured, tested and installed at NCMC, ACC and GMP during January 2012. Due to reliability issues only two of these BladeStop systems ran in production without fault one at NCMC and one at GMP. The saw installed at ACC was removed due to issues relating to the robustness of the mechanical latching components. This had not been a problem elsewhere but did require changing to ensure success of BladeStop industry wide.
MAR proposed redesign of BladeStop mainly focussed on operator enhancements to remove operator interaction for relatching, incorporate other continuous improvements and to retrofit, retest and reinstall all three systems back into ACC GMP and NCMC. The design enhancements focused on:

**Critical Enhancements to BladeStop Design**

- Redesign mechanical latching to be automatically actuated, removing operator interaction for relatching
- Increase saw speed from 720rpm to new industry standard of 1440rpm (new 4KW motors to be installed)

**Continuous Improvement Enhancements to BladeStop Design**

- Simplify brake location aiding operator use and reducing the need for alignment accuracy
- Simplified control circuit change out and improved robustness
- Improved arm band design and manufacturability to lower cost
- Simplify brake and trigger design to minimise complex components
- Introduce sensing readout for operator feedback
- Introduce illuminated buttons to indicate status of machine
- Improve electrical enclosure to more modular design

To achieve these design requirements an approach of using a pneumatic setup and high pressure air to fire a piston to clamp the blade was designed. This approach provided the following advantages.

- a lot less precision machined moving parts, reducing the complexity and potential areas for failure.
- the sliding motion of the mechanism to relieve tension on the blade was removed as it is no longer required. This eliminates the need for bearings and hence another possible area of failure.
- The oil bath and mechanical latching mechanism at the rear of the saw has been removed, the latching mechanism has been replaced by the pneumatic cylinder and is no longer required.
- the removal of the latching mechanism has meant that there is no longer the requirement for the operator to relatch the mechanism. This is a significant improvement since this area had been the cause of significant issues on previous saws. The mechanism now automatically resets itself after stopping the blade under spring tension internal to the pneumatic cylinder.

This design was implemented on the three saws for NCMC, ACC and GMP and along with:

- Upgrades to the electronics and electrical wiring to eliminate/combat noise that was being experienced onsite
- Upgrades to the armband/waist strap
- Upgrades to the software to accommodate the changes

- Was commissioned onsite where all three saws are now running successfully in production.

# Contents

# 1 Background

Project P.PIP.0260, Bladestop Phase 4 Commercial Trials, saw three Prototype BladeStop systems manufactured, tested and installed at NCMC, ACC and GMP during January 2012. Due to reliability issues only two of these BladeStop systems ran in production without fault one at NCMC and one at GMP. The saw installed at ACC was removed due to issues relating to the robustness of the mechanical latching components. This had not been a problem elsewhere but did require changing to ensure success of BladeStop industry wide.
It had also been noted that current industry standard for saw speed had changed from 720rpm to 1440 rpm especially where heavier beef bone cutting work is involved.
After a review of current status of the saws (23rd March 2012), MAR/MLA agreed that returning the current design BladeStop system to ACC to be actioned as a last milestone to complete P.PIP.0260 in lieu of the open day. The saw was re-installed at ACC with definitive operational guidelines based upon limitations of current design. Re-Installation of the ACC BladeStop using current design allowed for three systems to be tested in production while the next Phase of Development was completed.
The success of P.PIP.0260 Phase 4 Commercial trials had proven BladeStop under production conditions however had highlighted a need to redesign to improve Operator Interaction and other continuous improvements as noted below before a further roll out of BladeStop to the industry was commenced.
MAR proposed redesign of BladeStop mainly focussed on operator enhancements to remove operator interaction for relatching, incorporate other continuous improvements and to retrofit, retest and reinstall all three systems back into ACC GMP and NCMC.

**Critical Enhancements to BladeStop Design**

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**Continuous Improvement Enhancements to BladeStop Design**

- Simplify brake location aiding operator use and reducing the need for alignment accuracy
- Simplified control circuit change out and improved robustness
- Introduce new button press to relatch brake
- Improved arm band design and manufacturability to lower cost
- Simplify brake and trigger design to minimise complex components
- Introduce sensing readout for operator feedback
- Introduce illuminated buttons to indicate status of machine
- Improve electrical enclosure to more modular design

# 2 Project Objectives

The objectives of the project are as follows:

- Redesign BladeStop to New Concept with Operator Enhancements
- Critical Enhancements to BladeStop Design
    - Redesign mechanical latching to be automatically actuated, removing operator interaction for relatching
    - Increase saw speed from 720rpm to new industry standard of 1440rpm (new 4KW motors to be installed)
- Continuous Improvement Enhancements to BladeStop Design
    - Simplify brake location aiding operator use and reducing the need for alignment accuracy
    - Simplified control circuit change out and improved robustness
    - Introduce new button press to relatch brake
    - Improved arm band design and manufacturability to lower cost
    - Simplify brake and trigger design to minimise complex components
    - Introduce sensing readout for operator feedback
    - Introduce illuminated buttons to indicate status of machine
    - Improve electrical enclosure to more modular design
- Documentation. Detailed drawings mechanical, electrical, electronics, layouts,Training, Operation manuals, testing documentation, Risk Assessments & Legal review
- Upgrade ACC with new Bandsaw built to new improved design.
- Factory Testing NCMC saw at MAR. The system will be subject to an intensive testing plan to simulate one years production
- On-site installation and testing of ACC saw. The system will be tested under normal operation for a period of at least 2 weeks. Any event or occurrence will be recorded in a log book, in order to document and address any potential issue. The plant will then report on the operating performance of the system prior to retrofitting of GMP and NCMC saws.
- Upgrade GMP with new Bandsaw built to new improved design
- Factory Testing GMP saw at MAR.
- On-site installation and testing of GMP saw.
- Upgrade NCMC with new Bandsaw built to new improved design
- Factory Testing NCMC saw at MAR.
- On-site installation and testing of NCMC saw.
- MAR to provide system Videos, reports and documentation detailing the system, its components and operational procedure to be provided for industry dissemination and promotional purpose

# 3 Methodology

The objectives were achieved by completing the following Milestones:

**Milestone 1**
Redesign BladeStop to New Concept with Operator Enhancements

**Milestone 2**
Detailed drawings mechanical, electrical, electronics, layouts, Training, Operation manuals, testing, documentation, Risk Assessments & Legal review

**Milestone 3**
Build new ACC saw based on new improved design.

**Milestone 4**
Factory Testing ACC saw at MAR. The system will be subject to an intensive testing plan to simulate one year's production.

**Milestone 5**
On-site installation and testing of ACC saw. The system will be tested under normal operation for a period of at least 2 weeks. Any event or occurrence will be recorded in a log book, in order to document and address any potential issue. The plant will then report on the operating performance of the system prior to retrofitting of GMP and NCMC saws.

**Milestone 6**
Build new GMP saw based on new improved design.

**Milestone 7**
Factory Testing GMP saw at MAR.

**Milestone 8**
On-site installation and testing of GMP saw.

**Milestone 9**
Build new NCMC saw based on new improved design.

**Milestone 10**
Factory Testing NCMC saw at MAR.

**Milestone 11**
On-site installation and testing of NCMC saw.

**Milestone 12**
Final report

# 4 Results and Discussion

## 4.1 Milestone 1 & 2

Following installation of the three Bladestop saw's into NCMC, ACC and GMP during late 2011 and early 2012 and the issues that arose due to:

- the complexity of the mechanism.
- the speed of the motor.
- the operator intervention required to relatch the mechanism.

MAR reassessed the design of the mechanism and the saw as a whole with a view to:

- simplifying it from a mechanical point of view.
- making it more physically robust.
- eliminating the need for operator intervention.
- increasing the speed of the motor to the industry standard of 1440rpm to allow the saw to be used in heavier duty applications.

A number of approaches were considered. A design that continued with the existing mechanical latching setup, incorporating a servo motor to relatch the mechanism was modelled and discussed. It was felt however that this increased the complexity of the system and the likelihood of modes of failure without achieving some of the key criteria of simplification and improved robustness.
An alternative approach of using a pneumatic setup and high pressure air to fire a piston to clamp the blade was the next approach that was considered.
The figures below show the design. The design/operation of the mechanism is based on the following:

- high pressure air fills a chamber in a cylinder which is sealed by a valve controlled by a solenoid which is activated through the Bladestop control circuit.
- Once the Bladestop circuit fires, the solenoid releases the valve and allows the high pressure air to move into another chamber containing the piston that is attached to the moving clamping jaw.
- The first chamber is larger in size than the chamber containing the piston so once released the high pressure air causes the piston and hence the jaw to be fired forward to clamp the blade.

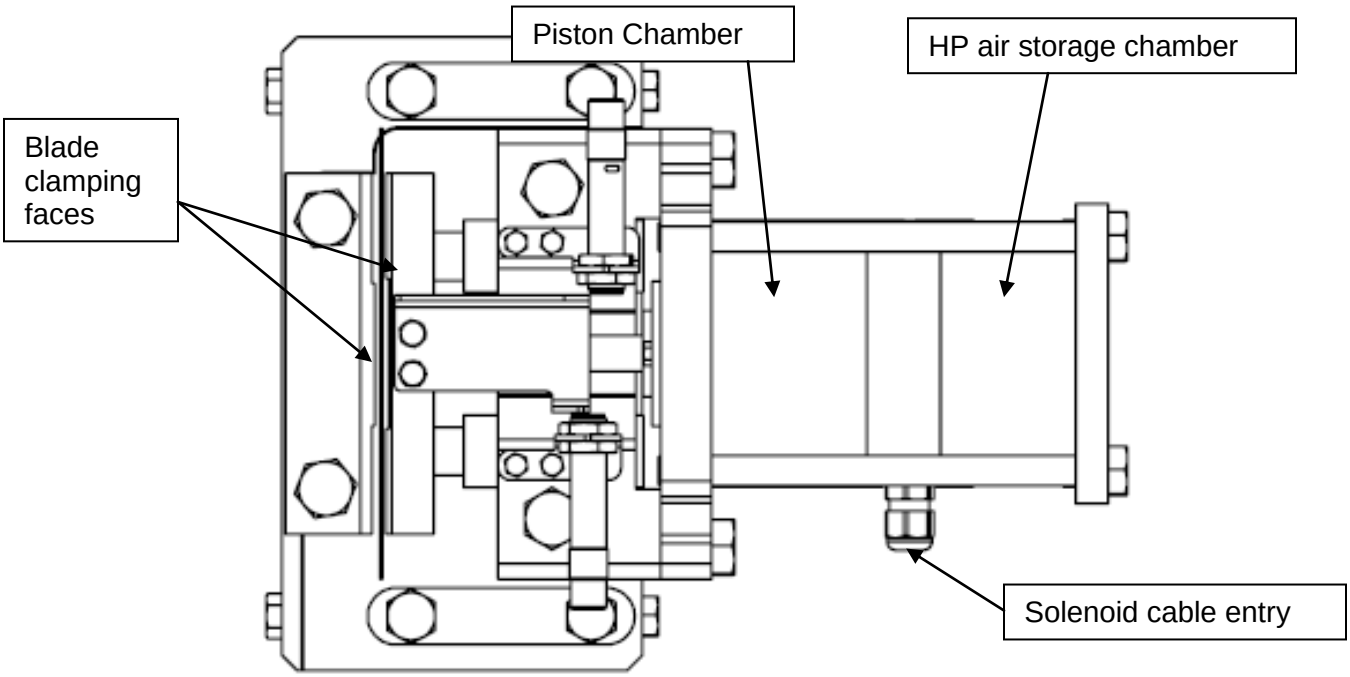


**Fig.1 Pneumatic Bladestop mechanism design**

The whole mechanism is significantly simpler than the previous design, in particular:

- there are a lot less precision machined moving parts, reducing the complexity and potential areas for failure.
- the sliding motion of the mechanism to relieve tension on the blade has been removed as it is no longer required. This eliminates the need for bearings and hence another possible area of failure.
- The oil bath and mechanical latching mechanism at the rear of the saw has been removed, the latching mechanism has been replaced by the pneumatic cylinder and is no longer required.
- the removal of the latching mechanism has meant that there is no longer the requirement for the operator to relatch the mechanism. This is a significant improvement since this area had been the cause of significant issues on previous saws. The mechanism now automatically resets itself after stopping the blade under spring tension internal to the pneumatic cylinder.

The other significant modifications that have been made to the design are:

- the motor speed has been changed from a 700rpm motor to a 1440rpm motor.
- An air intensifier has been added to the saw, this intensifies factory supplied air of around 5 bar to approximately 21 bar which is suitable for mechanism activation.
- The arm strap has been replaced by a waist strap. This has eliminated the need for the swivel overhead conduit and the ‘curly’ cord getting in the operators way when using the machine. The ‘curly’ cable will now attach underneath saw table. The waist straps are purchased premade and modified to suit Bladestops purpose. This has eliminated issues

that were being experienced with the arm straps that were fabricated at MAR and became unreliable onsite after a period of use.
- The design of the PCB and corresponding program has been modified to suit the new mechanism. This has simplified the PCB without compromising the safety of the system.
- The electrical enclosure layout has been upgraded to suit the new mechanism design. The layout is now more compact allowing the PCB to be mounted on the back plane of the panel instead of on the door of the enclosure as it has been in the past.
- The operator interface through the interaction with the LCD screen as been upgraded to suit the new mechanism and provide the operators with relevant information on the status of the machine.

The detailed design documents required as part of MS2 were included as part of the MS2 and are attached as appendices to this report.

## 4.2 Milestone 3 & 4

Following the design of the new mechanism, the following occurred to convert the ACC band saw, that had been returned to MAR, to suit the mechanism and design:

- The old mechanism was removed and solid stainless plate ‘cleaned up’ and drilled and tapped to suit the new mechanism.
- The new mechanism was fabricated and fitted to the solid stainless steel plate.
- The air intensifier was fabricated and installed in a stainless steel enclosure on the rear of the machine.
- The electrical panel was re configured and re wired.
- The 700 rpm motor was replaced by a 1440rpm motor
- The waist strap was sourced and modified to suit our application
- The saw was modified to suit the new location of the waist strap connection
- The PCB program was updated to suit the new design and improve the operator interface with the machine through the LCD screen.

The images below show these various components installed at MAR on the Bladestop to be sent the Australian Country Choice.

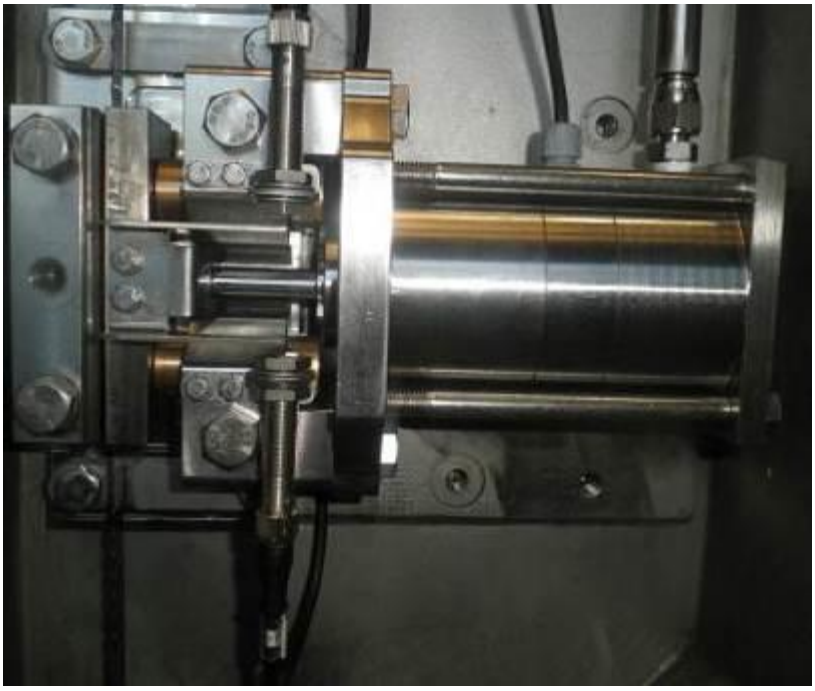

**Fig.3 New Bladestop mechanism installed into the ACC saw**

**Fig.4 New Bladestop mechanism installed into the ACC saw**

**Fig.5 Air intensifier installed into the ACC saw**

**Fig.6 Air intensifier stainless steel box installed on the ACC saw**

**Fig.7 New waist strap**

**Fig.8 Waist strap connection**

**Fig.9 Waist strap connection**

**Fig.10 Upgraded Electrical Enclosure**

Following the build of the saw it was subject to a 1000 trip test in order to verify the integrity of the mechanism and ensure that the likely modes of failure were able to survive repeated actuation. The thousand trips were performed without meat and high speed videos were taken every 20 trips to confirm the mechanism was reacting and clamping the blade within the desired time frame. Satisfied with the integrity of the mechanism following the 1000 trip test, testing with meat was conducted. In addition the cast iron wheels were swapped for stainless steel wheels that are required at ACC. The testing showed that the stopping time with stainless steel wheels and when cutting meat was longer than is acceptable. Various changes were made to the air pressure and the clamping faces to improve this stopping time. The image below shows the outcome of the modifications that were machined into the clamping faces to stop the blade within the required time without actually breaking the blade.

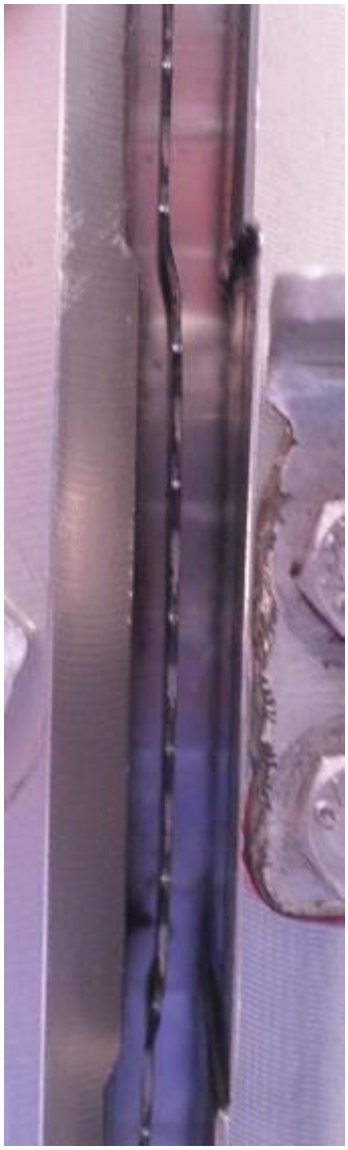

**Fig.11 Modified Clamping faces**

The results of the tests following the modifications showed that the blade was stopped in within an acceptable time without breaking the blade. Sausage tests were conducted and a resulting cut depth of 2 – 2.5mm recorded.
It can be seen from the above image that a trip does damage the blade and in a production environment would require the blade to be replaced.
An additional positive to come out of this testing was that due to the improved conductivity provided by the waist strap the sensitivity of the sensing circuit could be reduced without affecting the performance of the system. This has meant that normal washing up gloves can be used to operate the machine allowing the thicker and more cumbersome gloves required in the past to be replaced.

Hence with acceptable results from the 1000 trip test, the 100 trip test with meat and the sausage test MAR prepared the saw for transport to ACC.

**Fig.12 Saw ready for shipping to ACC**

## 4.3 Milestone 5

The saw was returned to ACC on the 21/09/12 and MAR attended site on the 24/09/12 to conduct operator and maintenance training on the upgraded system.
The saw was put into production on the 25/09/12 and ran successfully. Some issues did occur however and these are listed below:

- Wire breakage in the waist strap and snapping of waist strap connector, the strap was replaced and the original repair and is on site as a spare.
- Motor burn out due to ACC's operating procedures of continually starting and stopping the saw. This was over come by retrofitting a 'Bladeguard' Mechanism that is a pneumatically operated guard that requires foot pedal activation to allow access to the saw.
  The motor was replaced and the saw has run successfully in production since this time. At this point the 1400rpm motors on the GMP and NCMC saws were left as they were as it was felt that motor burn out would not be an issue due to fact that NCMC and GMP do not start and stop their saws during production.

The waist strap and connectors were to be monitored during the installation and initial use of the saws at GMP and NCMC to determine if there is a need to upgrade this area further.

The images below show the saw installed at ACC.

**Fig. 13 Images of the saw installed at ACC.**

## 4.4 Milestone 6, 7

Following the installation of the Bladestop Bandsaw at ACC work was commenced on the saw for Gundagai Meat Processors and the following was completed by the end of October 2012:

- Wiring of new electrical panel and fitting of panel to saw
- Wiring of saw
- Fitting of Bladestop Mechanism
- Fitting of pneumatic intensifier and associated plumbing

Factory testing of the saw followed, this included 50 trip tests where stoppage time was recorded along with the high speed video which showed that the mechanism was stopping the blade within the required 15ms.

Following successful Factory testing of the saw it was sent to GMP in early December 2012 and installed and commissioned in the boning room. The saw ran in production for a brief period before experiencing issues with the electronics and arm band. The saw was supplied with the same waist strap that was supplied with the ACC bandsaw, this is shown in the image below:

**Fig. 14 Waist Strap supplied with ACC and GMP saws**

As can be seen from the image this waist strap is of the type used for medical electro therapy/ muscle relaxation. The move to this waist strap from the previous arm band, shown in the image below, was made following comments from processors that the arm band was uncomfortable to

wear and cumbersome to use. This combined with the fact the armband was difficult and time consuming to fabricate lead to the use of the medical style waist straps shown above.

**Fig. 15 Original Arm band**

Issues have arisen however with the waist strap not being robust enough for use in the boning room environment. Problems were experienced with wire connections breaking, plastic securing clips breaking, the connection to the saw being difficult to locate and connect and tracking of the electrical signals between the two conducting pads due to moisture in the belt itself. The images below show the connection of the waist strap to the saw.

**Figs. 16 Connection point for waist strap to saw.**

With all these issues in mind a new solution for attachment of operator to the saw was required and the design shown in the images below was developed.


**Fig.17 Images showing the new waist strap design including Contact Block, elastic waist strap, cable and new connector**

**Fig. 18 Contact Block**

**Fig. 19 Press Stud connection of Contact Block to elastic strap**

**Fig. 20 Attachment to waist**

**Fig. 21 New Connector**

As can be seen the new waist strap setup consists of a robust, sealed contact block, the cable is secured inside the block with a ferrel and once the wires are connected to the back of the stainless steel contact pads the inside of the block is filled with epoxy. The Contact Block is secured to the off the shelf waist strap with a press stud and is attached to the body as shown. As an alternative a shorter elastic strap could be purchased and used as an arm band if desired. The final image shows the new connector on the end of the waist strap cable, this is more robust and easier to attach than the connectors that have been used previously. Three of these straps were fabricated and sent to ACC where they were used in production.

## 4.5 Milestone 8,9,10&11

Following some modifications to the circuitry to eliminate noise issues factory testing of the NCMC saw at MAR was completed and the saw was sent to NCMC.
Visits were made to ACC and GMP while the saw was being commissioned at NCMC to re-route wiring, fit upgraded boards and download new software following the success of the testing at MAR. The saw at GMP was put into production and SAT sign off achieved from Peter McDonald, Maintenance Manager, on the 21/2/13. The saw was fitted with new waist band and GMP modified the plug and socket on the machine to a more robust 'general purpose' setup as shown in the images below (this form of plug and socket was subsequently fitted to the ACC and NCMC saws also). While this was taking place MAR's Engineers also travelled to NCMC where they tested and recommissioned the saw before conducting training on the operation of the new mechanism with maintenance and operator staff. This saw was put into production on 15/2/13. The image below shows the saw in use at NCMC.

**Fig.22 Modified plug on waist strap**

**Fig.23 Modified plug and socket**

**Fig.24 Bladestop in use at NCMC**

The saw at GMP lasted less than a week in production before intermittent tripping was experienced and erroneous alarms were displayed on the operator screen. Further analysis on site established that GMP has a very 'noisy' supply and capacitive coupling was being introduced which was causing issues with the signals on the saw. Testing was carried out at MAR's workshops, firstly to simulate the noise and capacitive coupling and then establish methods to filter and eliminate both these issues. A suitable filter circuit was devised and fabricated and proven to work on the machines at MAR. This was fitted to the saw at GMP and this Bladestop has been operational since 28/3/13. For uniformity these upgrades were made to the saws at ACC and NCMC and they are both currently running in production without issue.
GMP operators had issues with the waist strap/arm band from a comfort point of view and began development of their own arm band to incorporate the contact block. The image below shows what has been developed. A recess in the arm band has been created to mount the sensor and the size of the armband increased to suit the size of the operators on site. Three of these armbands have been manufactured and GMP have been using their saw since this time (June 2013).

**Fig.25 Arm band developed at GMP.**

The saw at GMP was put into production today using this arm band and has run successfully.

# 5 Success in Achieving Objectives

Project P.PIP.0260 Phase 4 Commercial Trials proved BladeStop could run under production conditions but also highlighted a need to redesign to improve operator interaction and robustness and reduce the complexity of the saw. This Project P.PSH.0618 addressed these issues by adopting an alternative mechanism utilising a pneumatic setup and high pressure air to clamp the blade. This approach resulted in a significantly simpler mechanism which addressed the projects objectives and reduced the complexity and potential areas of failure.
As a result of this the three saws have been successfully retrofitted, retested, reinstalled and recommissioned on all three processor sites these being Australian Country Choice, Gundagai Meat processors and Northern Coop Meat Company.

# 6 Conclusions and Recommendations

In this project MAR has redesigned the previous BladeStop and focussed on operator enhancements to:

- remove operator interaction for relatching,
- incorporate other continuous improvements
- retrofit, retest and reinstall three systems back into the following three processor plants:

    - ACC - Australian Country Choice
    - GMP – Gundagai Meat Processors
    - NCMC – Northern Co-Operative Meat Company

The successful re-development, re-deployment and production trials of the new BladeStop systems with enhanced design has proven BladeStop is now ready for further funded industry roll-out and impending commercial installations.
As further evidence of the success of this latest design, ACC one of the three trial sites committed and placed orders for nine (9) new BladeStop systems. These systems have been have now been commissioned at ACC and are progressively being put into production following site specific modifications to the table slide. NCMC and GMP have also conveyed very positive expressions of interest with regards to the purchase of new systems in the near future. Overall recent success of the BladeStop development has resulted in very positive expressions of interest and intent to proceed with commercial systems industry wide.

However, it is clear that for BladeStop to be commercially successful in the near future, BladeStop needs to be installed tested and trialled at more sites to fine tune the development in preparation for full commercial release to create the necessary confidence for processors. Previous installations have shown that variations in processing needs, plant production, plant practices and preferences have created difficulties in the design process resulting in ongoing variations in the design to accommodate all needs and practices. It is recommended that MLA proceed with the proposed Phase 6 roll-out project which will allow these variations to be accommodated and allow the BladeStop system to be tested under production conditions over a range of processing sites each with their own needs and differences.