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Prepared by: Craig Daff
Cedar Creek Company

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Meat and Livestock Australia Limited
PO Box 1961
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Automation and Sorting of Carcases into and out of chillers

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Abstract

This project was initiated as part of a program to improve the efficiency of plant operations and reduce processing costs within stock plants across the industry.

There is a vision to automate manual functions and processes within the slaughter, carcase chiller, and boning room operations. The primary business benefits driving this initiative are three-fold:

To improve the efficiency,

Increase carcase traceability within plant operations, and

To reduce on-plant labour costs.

There is an area of labour saving identified in the existing manual processes around carcase chiller marshalling and sorting, carcase traceability, and the flow of carcasses into the boning room via an unmanned station. These manual tasks are by nature repetitive, and prone to errors.

Executive summary

The laborious and sometimes inaccurate task of pushing carcasses into chillers will be negated through the use of RFID technologies interfaced with pneumatic rams and sensors.

The new Production Scheduling & Chiller Marshalling Control Software will utilise slaughter floor data and unique RFID numbers on the carcase skids to facilitate a pre-determined Chiller Load Sequence based on selected grouping criteria set by the Operator. The solution will also allow for manual operation via the on floor scheduling HEC touch screen.

With appropriate data available from within the The host processor Kill Floor and Inventory systems, this will enable the automated sorting of carcasses into specified chillers based on pre-set criteria such as:

- Weight and Fat score range
- MSA eligibility
- Owner of the Carcase
- Producer of the Carcase
- Animal Health Status Alerts
- Selected Grades and/or Markets

This will be achieved by appropriately placed RFID readers, control software, and a mechanical method (to be provided by The host processor Abattoirs) to load and unload the chiller rails.

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1 Background

In a typical meat processing facility, carcases post Grading are generally conveyed by a continuous chain past a number of chillers. Each chiller comprises multiple rails and the loading of individual carcases into each chiller and onto each rail is mostly completed using manual labour. Any manual handling in an abattoir has its own set of health, safety and contamination risks.

Automated animal traceability at meat processing plants usually conforms only to NLIS requirements where the carcase is identified by its NLIS transponder (in the case of bovine kill) or by its PIC or Mob identification (in the case of ovine kill) at the point of slaughter. The host processor implemented a carcase tracking system on the Lamb slaughter floor using RFID equipped hooks to extend traceability to the end of the slaughter where the carcase is graded.

By extending carcase tracking into the Chillers and down to the Boning room The host processor will determine any efficiencies that can be gained with tracking carcases beyond Grading. In addition to RFID transponder developments, and additional data capture stations, some modifications and changes to the host processor chiller hardware and the plant's software, would need to be required for chiller automation to be trialled.

The Project identified a number of areas in **which innovation in control and automation systems** could benefit all meat processors.

1. Automation of carcase handling - With the addition of automated rails into and within individual chillers, manual handling and human intervention can be eliminated. This has resulting benefits in food safety, workplace health and safety and plant productivity due to streamlining.

2. Integrating control software systems – Aggregating vast quantities of data such as slaughter schedules, carcase yield, boning room agendas and customer requirements could enable order fulfillment across multiple chillers. Considerable labour savings could also be achieved through the use of auto control systems for chiller loading and unloading sequences.

3. Traceability - The use of Hook RFID and individual carcase tracking to the boning room entry will provide greater traceability per carcase and the opportunity to provide additional data per carcase for grower feedback and flock managment. Plus the recording of carcase information per carcase, could deliver close to real-time disease monitoring to Animal Health Australia.

This project was initiated as part of a program to improve the efficiency of plant operations and reduce processing costs within stock plants across the industry.

There is a vision to automate manual functions and processes within the slaughter, carcase chiller, and boning room operations. The primary business benefits driving this initiative are three-fold:

- To improve the efficiency,
- Increase carcase traceability within plant operations, and
- To reduce on-plant labour costs.

There is an area of labour saving identified in the existing manual processes around carcase chiller marshalling and sorting, carcase traceability, and the flow of carcasses into the boning room via an unmanned station. These manual tasks are by nature repetitive, and prone to errors.

2 Project objectives

The primary objectives of the project were to improve the efficiency of plant operations and reduce processing costs within stock plants through the use of;

- Chiller Management Software and programming of PLC systems to read hook RFID's and control chillers to direct carcases in accordance with a current plan. These PLC systems will need to be integrated with chiller marshalling software to ensure successful integration between software, RFID and mechanical equipment.
- Independent Mechanical Rail Control. Accumulating stepping chains will be provided for to enable loading and unloading of rails in any desired pattern. Each chain will be individually controlled so that the chain is in motion only when carcases are to be indexed along the rail thereby keeping energy requirements to a minimum. It will enable the loading and unloading pattern of carcases to be independent of each other according to boning room requirements.
- Improved Occupational Health & Safety through a reduction in injuries particularly back injuries. The improved individual rail control will make automation of chillers more feasible to improve management of production requirements and remove the need for labour to push carcases. This will assist to reduce industry workers compensation rates.
- Improved Food Safety by removal of human contact involved in traditional loading/unloading of chillers. Human hands will not touch the carcases from the grading station to the boning room.
- Electronic traceability without RFID tagging of livestock. Information regarding carcases entering the boning room will be traceable through RFID scanning against carcases as they enter the boning room. In the event of any animal disease incident the exact location of each carcase will be obtainable instantly.

Improved Feedback to Industry and Producers. Dispositions made by inspectors will be recorded against each carcase on the slaughter floor. These dispositions and data from the grading station will be available to upload to a central database to assist producers measuring yield and animal welfare characteristics of their livestock.

3 Methodology

The laborious and sometimes inaccurate task of pushing carcasses into chillers will be negated through the use of RFID technologies interfaced with pneumatic rams and sensors.

The new Production Scheduling & Chiller Marshalling Control Software will utilise slaughter floor data and unique RFID numbers on the carcase skids to facilitate a pre-determined Chiller Load Sequence based on selected grouping criteria set by the Operator. The solution will also allow for manual operation via the on floor scheduling HEC touch screen.

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4 Project Deliverables and System Operation

This solution covers the supply of an integrated automated chiller loading/unloading system between the existing grading station and boning room. Cedar Creek have provided software modules to deliver the below functionality.

- Integration of the existing on-floor systems and the new software control systems for automated chiller sorting, unloading and boning room entry.
- A visual representation of each chiller showing stock of lambs, colours for mobs, markets, day of kill, and specifications. This can be viewed from either of the Production/Chiller Scheduling HEC's.
- Chiller loading and sorting is controlled by the new Chiller Automation Module in Foodchain, with a manual over-ride possible at either of the Chiller Marshalling stations on the floor; this is based on the location of the carcase on the chain, the software will activate a puller to direct the carcase onto the appropriate chiller rail.
- The system will allow for manual pushing of carcasses from Chillers 4, 5, 7 and/or 8 (via pass-through of Chillers 9, 10, 11, 12, or 14) through to the boning room. This may be happening at the same time as lambs are being killed and loaded into other automated chillers. The lambs being pushed through the non automated chillers, or an automated Chiller that is not scheduled for filling or unloading during production may at a later date also be identified through other RFID wands where the lambs are presented separately for identification.
- If production is running, the timing of the manual carcases being transferred manually to the Boning Room is controlled by an operator.

- All functionality required to record, monitor, and maintain the tracking of individual carcases from the existing grading station, through Chillers 10, 11, and 14, and up to the boning room is provided.
- An exception report will be provided to support a process to manage (manual) carcasses diverted to Chillers 4, 5, 7, and 8. The identifiable characteristics of these carcasses will be maintained, however the carcase will be deemed loaded out where the RFID enabled hook has not been reused for a variable period (default setting 7 days).
- An alarm will sound, in order for the chain to be stopped if the RFID wand/s located prior to the chillers fails to read.
- The software provides all required signal processing to and from mechanical components.
- The software will provide functionality to control the marshalling criteria based upon the below;
  - Weight and Fat score range
  - MSA eligibility
  - Owner of the Carcase
  - Producer of the Carcase
  - Animal Health Status Alerts
  - Selected Grades

System Operation

The operator will have the option of running the system in manual, semi –auto or fully automatic. It must be remembered that not all chillers have walking beams installed for auto lamb loading. It will be a user friendly system as many users will have limited computer experience.

The system will keep a check on how many lambs have gone to which chillers (automated and non-automated), however accuracy can only be guaranteed for those carcasses that have passed a scanning point and/or entered an automated chiller. Available chillers for loading will be nominated at the commencement of each shift.

Via the SCADA HEC on the floor a high level software screen will present in a form to provide a visual of the load out facility. The operator will be able to drill down from the high level chiller overview to individual body data

Manual is where lambs are diverted post the grading scale; as the required Market Grade has not been met, to a nominated manual chiller – this direction will stay as default on the grading station until the operator changes. The system will automatically pickup the previous default where there is a change of mobs on the same shift.

Semi-automatic is where loading and unloading orders are input into the system by an operator on-floor and/or off-floor. Operator access restrictions need to be in place and logged with the ability to review. Through the use of colours, letters and numbers the screen will

present the operator with some basic details of what is in each chiller with further summaries/details available by drill down. These basic details should include the following: Date/s of Kill, Number in Chiller, Number of Customers/Mobs plus average statistics on weight and fat class.

In working function it will also show whether some of those lambs have been assigned to the boning room for processing. The Drill down will also show when these lambs are expected to be processed.

The software will enable the control of the boning room input gate to direct carcases to alternative lines in the boning room.

5 Installation, Results & Discovery

The installation of the project at The host processor commenced November 2011. The initial stages included all parties gaining an understanding of the functionality required including mechanical control, SCADA and PLC control and integration into the Cedar Creek Food Chain ERP system for recording of Carcase data and entering of the daily Chiller Load and unload schedules.

A number of variations were made to the code and mechanics once the project initiated as further knowledge was gained of the complexities of such a project.

In the early stages there was no automated control of the main chain leading from the Chillers down to the Boning room. However, after careful consideration it was decided to include the control of this chain within the Chiller Automation SCADA PLC control system so the chain could be started, stopped and the speed changed to coincide with Carcasses unloading out of chillers and feeding into the Boning Room.

There were issues around how backlogs would be detected when feeding into the Boning Room, how accurate this would be and how this would affect Carcasses being unloaded. Discussions were held on just how this would operate and a final mechanical method of detecting backlogs was decided and implemented.

The initial project deliverables included a method to simply weigh carcasses at the Boning Room input scale and sort them down a selected Boning Room lane automatically. The Lane number for each Carcase was set when the Chiller Unload schedule was created for the group(s) of carcasses residing in the Chiller. ie; each group of carcasses were given a Boning Room Lane number when the Unload schedule was set for the day.

However, during the course of the project it was noted that a method to resort carcasses based on a new set of criteria at the Boning Room entry was required. This maybe due to a late change in Boning room production requirements or an emergency bone required for a particular customer for example. A project variation was raised and several specification versions were drafted before settling on the functionality required. In essence the new functionality provides The host processor Abattoirs with the ability to sort Carcasses down different Boning Room lanes right at the scale where carcasses enter the Boning room. For example if the plant decides that they will be Boning light carcasses down Boning Room Lane 1 and heavy carcasses down Lane 2 then they can set an override for the day and the system will ignore the unload schedule that may have been set. The system will individually weigh each carcase at the Boning Room entry and based on the weight from the scale sort the carcase down the correct lane.

This additional functionality provides The host processor Abattoirs with the flexibility to control carcasses destined for Boning at a moments notice. The control for Boning Room re-sorting can be controlled from either, on the floor, or off the floor via the Food Chain system.

There were also a number of areas of the chain where there was no automated control. For example the exit of Chiller 14, the main chain between Chiller 14 and the Boning Room scale and the 2 Boning Room Lanes post the Scale. The control of all of these areas by the SCADA/PLC system was also included in the variation as it was determined that without SCADA control at these points the system would potentially fail as SCADA would not know where carcasses reside on the chain. There were additional mechanical changes required, additional pneumatic and electrical equipment installed and changes to the SCADA control program to suit.

Gravity fed areas of the chain also presented significant challenges. Problems with false triggers and/or double triggers of sensors or lever switches were caused by carcases swinging when they dropped down a gravity rail. When this occurs the reliable tracking of carcases is lost and invariably carcases would then end up on the exceptions rail in the chiller. Wherever possible carcases must be moved via a driven chain as this allows the SCADA tracking software to determine the exact location of each carcase at all times.

One of the most significant challenges was testing and trialling the system throughout the installation and commissioning phase. To achieve reliable test results it was agreed that the only reliable way to test was by using real carcasses in a production environment. While there is no doubt this method of testing was very thorough, it does have limitations as the automated chiller was not always available due to production constraints. We also found that we only had very small windows of opportunity to test sorting at the Boning room scale as the automated scale at the Boning room was not sorting fast enough in the beginning to feed the Boning room with carcasses.

Points of Note:

The most thorough and effective testing needs to occur within a production environment. However the testing needs to be well managed and organised to achieve productive results.

All mechanical areas of the Automated system need to be load tested to ensure they will stand the rigours of an automated environment. Reliable and precise mechanical operation of the system is essential to the success of an automated chiller marshalling system.

Automation of the entire chain by the SCADA system from the Kill floor right through all the chillers and into the Boning room is essential.

A detailed specification on system requirements needs to be very well defined at the beginning of the project

Thought needs to be given to the type of switch used to detect carcasses passing onto Chiller rails based on the type of rail and type of skid used within a plant. Using a switch that is not suited to the rail and skid hardware can lead to imminent failure.

5.1 Software Development & System Architecture

Development of the Automated Chiller marshalling system involved two main aspects;

1. Cedar Creek Food Chain development to cover;
    a) Collection of carcase characteristics captured on the floor and via the Livestock processing modules
    b) Data Input screens for creating of Sort Group rules and priorities to be applied to each carcase during the daily kill. See Figure A below
    c) Browser screens to view the Sort Groups and Priorities. See Figure B below
    d) Data Input screens for turning Chillers On and Off for Chiller Marshalling
    e) Application of the Sort Group rules to each carcase as they are processed and assigning of the applicable Sort Group to each carcase.
    f) Interface to the SCADA system to provide individual carcase details and the Sort Group each carcase belongs to
    g) Interface from the SCADA system to record in inventory the exact rail and position location of each carcase.
    h) Data Input screens to control Chiller unloading based on a set pre-determined unload order. Interface to SCADA of unload order. See Figure C below
2. Cedar Creek SCADA development to cover;
    a) Interface from Food Chain to accept individual carcase details and the Sort Group each carcase belongs to
    b) Input screens to monitor, set and check pneumatics, sensors & chiller characteristics. See Figure E Below
    c) Browser screens to view the Chiller contents and layout. Browser screens are real time updating as carcasses are being loaded. See Figure F below
    d) User Input screens available from On-Floor to set carcase grouping characteristics and override Sort group priorities that may have been set off the floor in Food Chain. See Figure G & H below
    e) Sorting of carcasses onto rails and grouping them together based on the rules applied. Triggering of pneumatics for gates and interface to sensors and lever switches to determine the location of each carcase.
    f) Alarms and log files to help troubleshoot mechanical problems should they arise

g) Automated Carcase unloading via the interface to Food Chain through a pre-determined unload order or via the On-floor SCADA system by manually selecting groups for unload. See Figure I below

h) Provision of an automated Boning Room Input module to record the cold weight of each carcase as they enter the Boning room. Triggers to pneumatics to move the automated walking beam. See Figure J below

Figure A

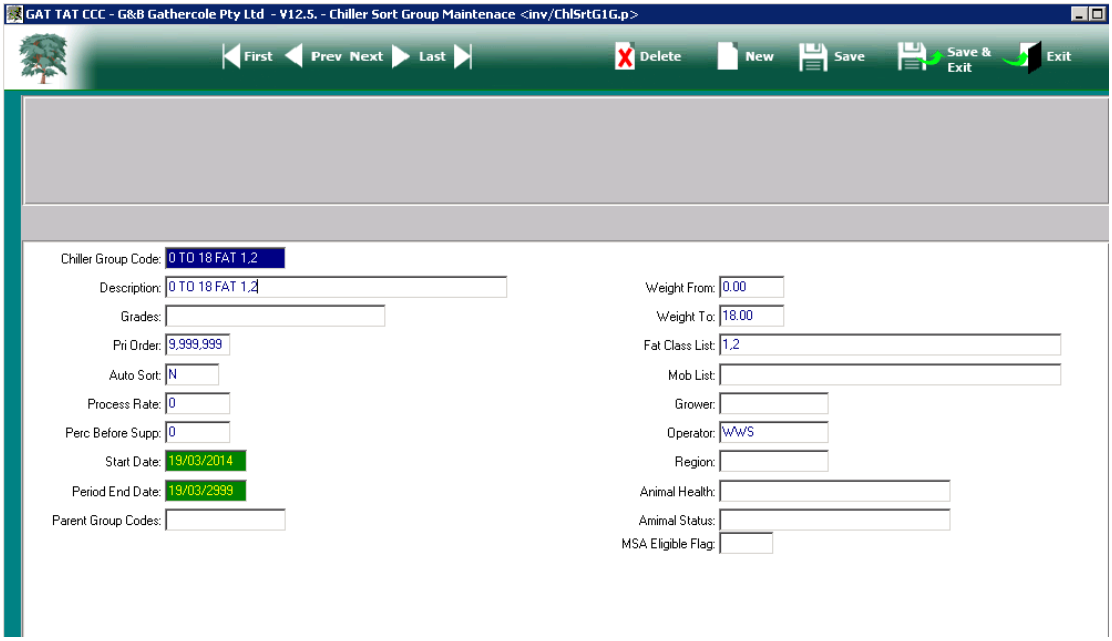


Figure B

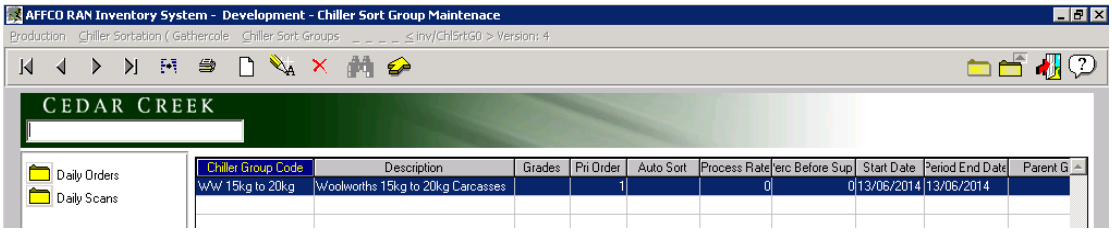


Figure C

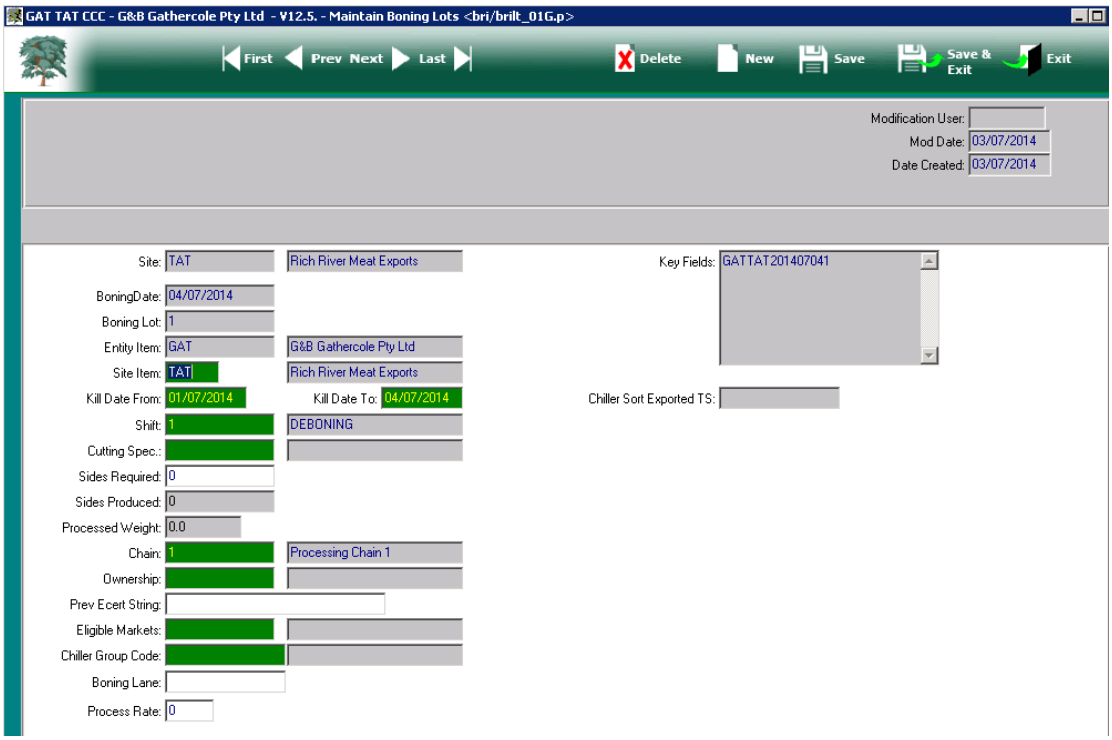


Figure D

Date	Run Batch	Carcass Entity	Carcass Site	Carcass Kill From	Carcass Kill To	Shift No.	Boning Group Specification	Sides Required	Sides Boned	Weight Boned	Ownership	Chiller Group	Boning Lane	Process Rate
16/06/2014	1	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	2	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	3	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	4	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	5	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	6	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	7	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	8	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	9	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	10	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	11	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	12	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	13	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	14	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	15	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	16	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	17	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	18	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	19	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0
16/06/2014	20	GAT	TAT	13/06/2014	16/06/2014	1		0.00	0.00	0.0				0

Figure E

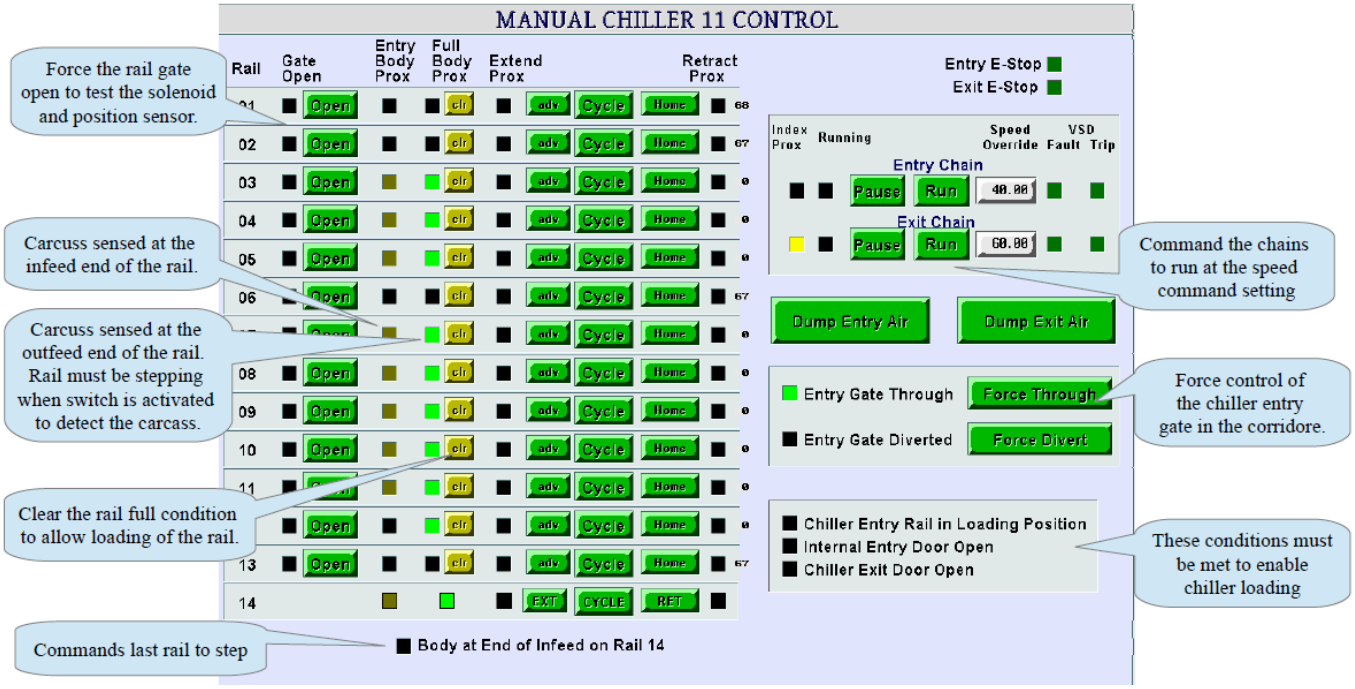


Figure F

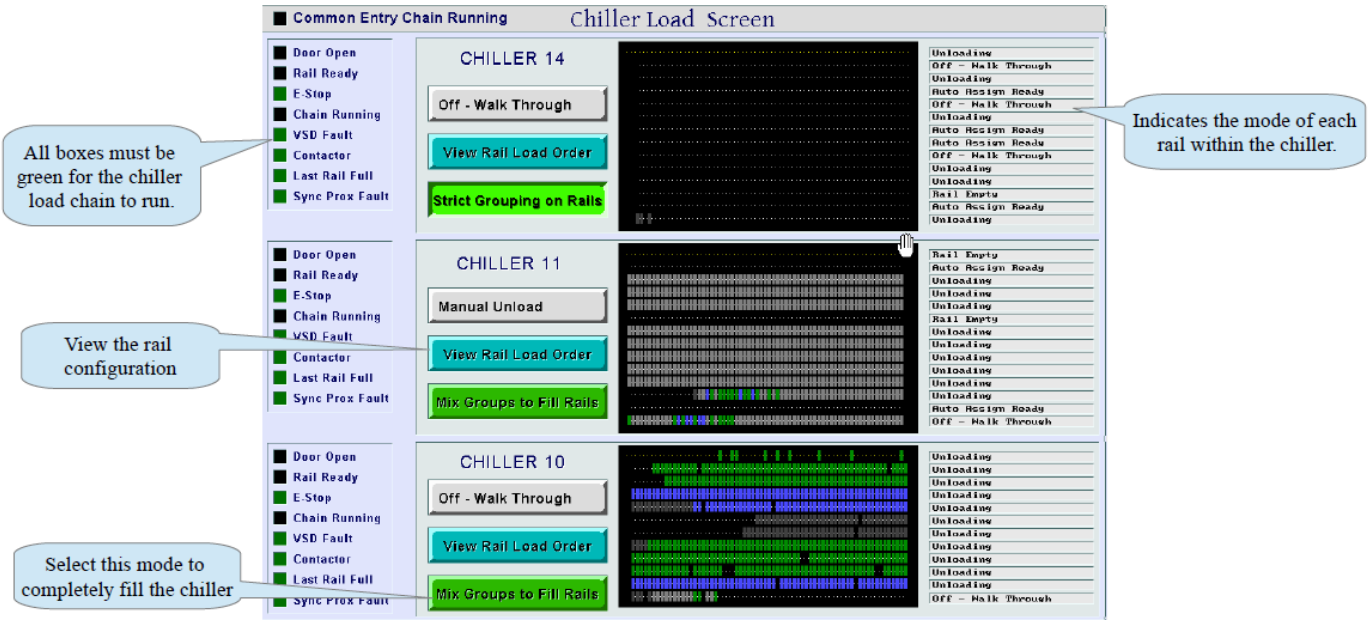


Figure G

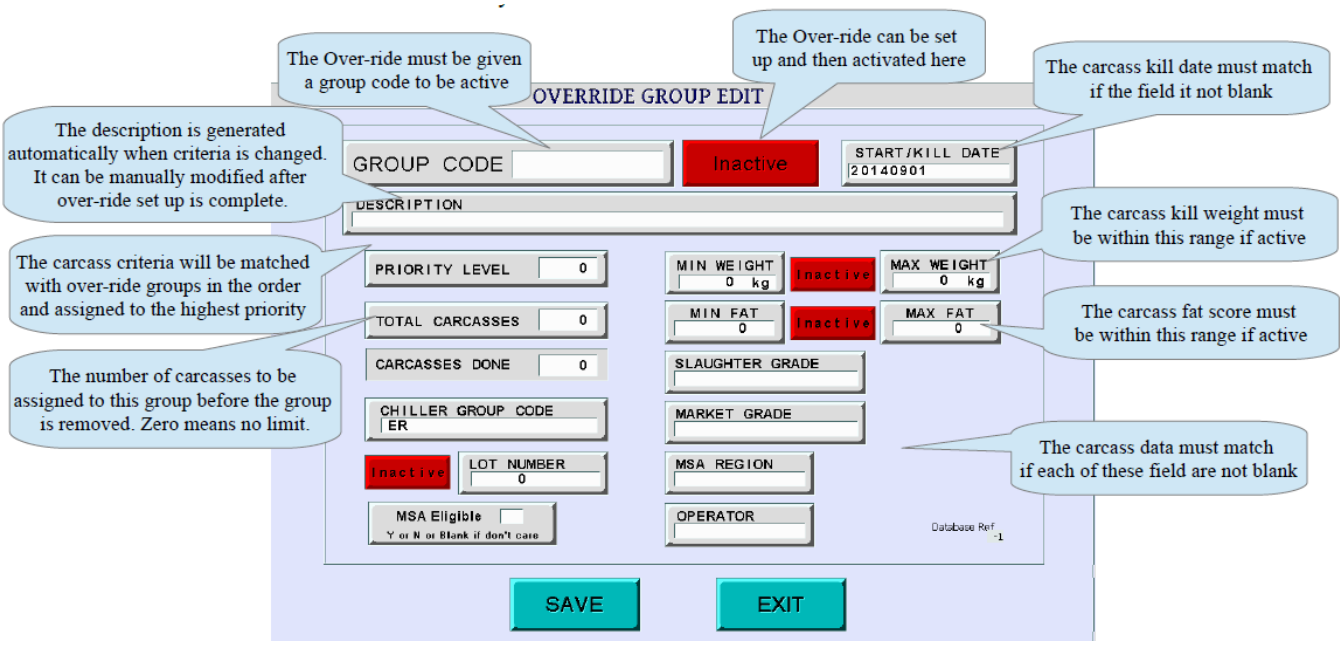


Figure H

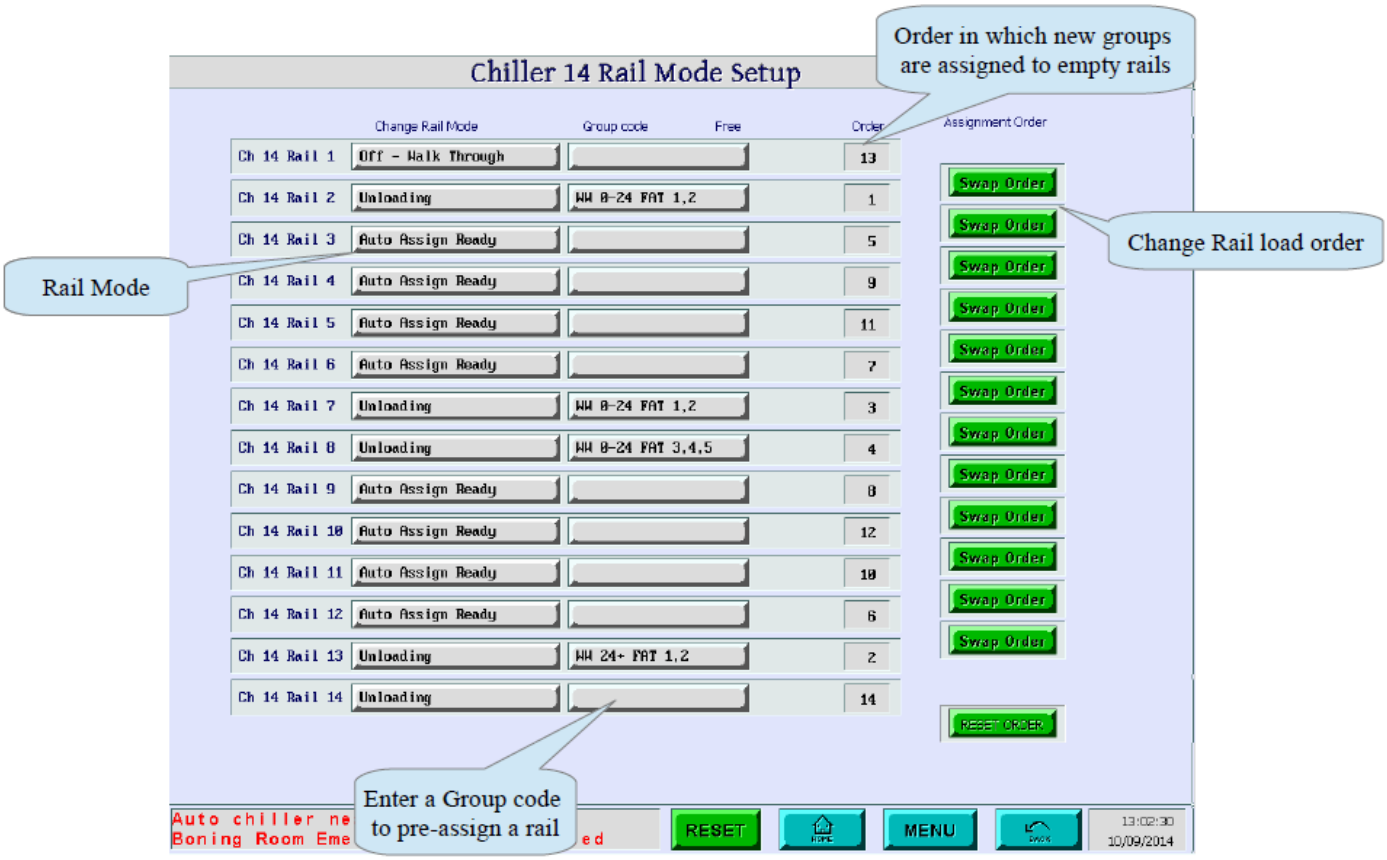


Figure I

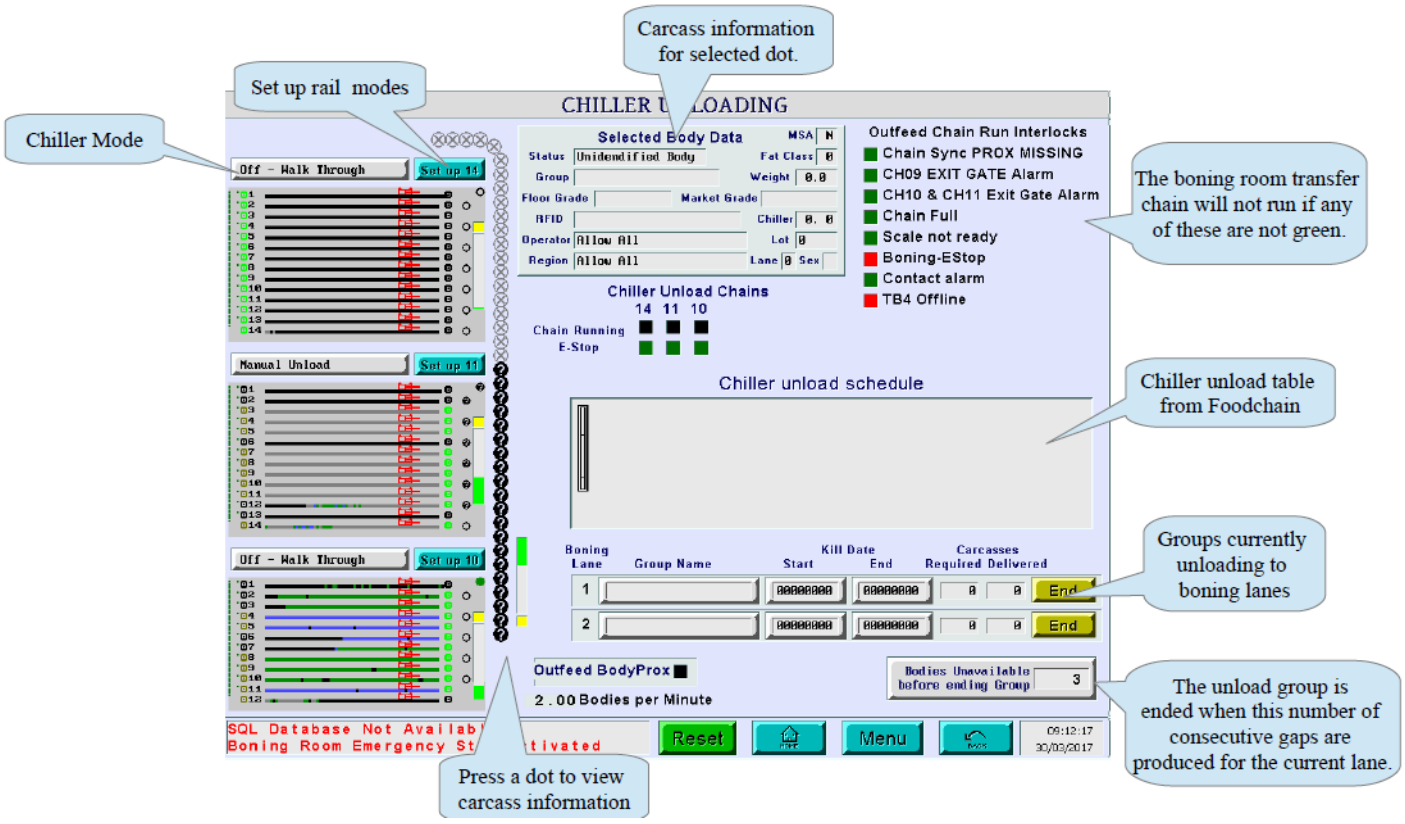
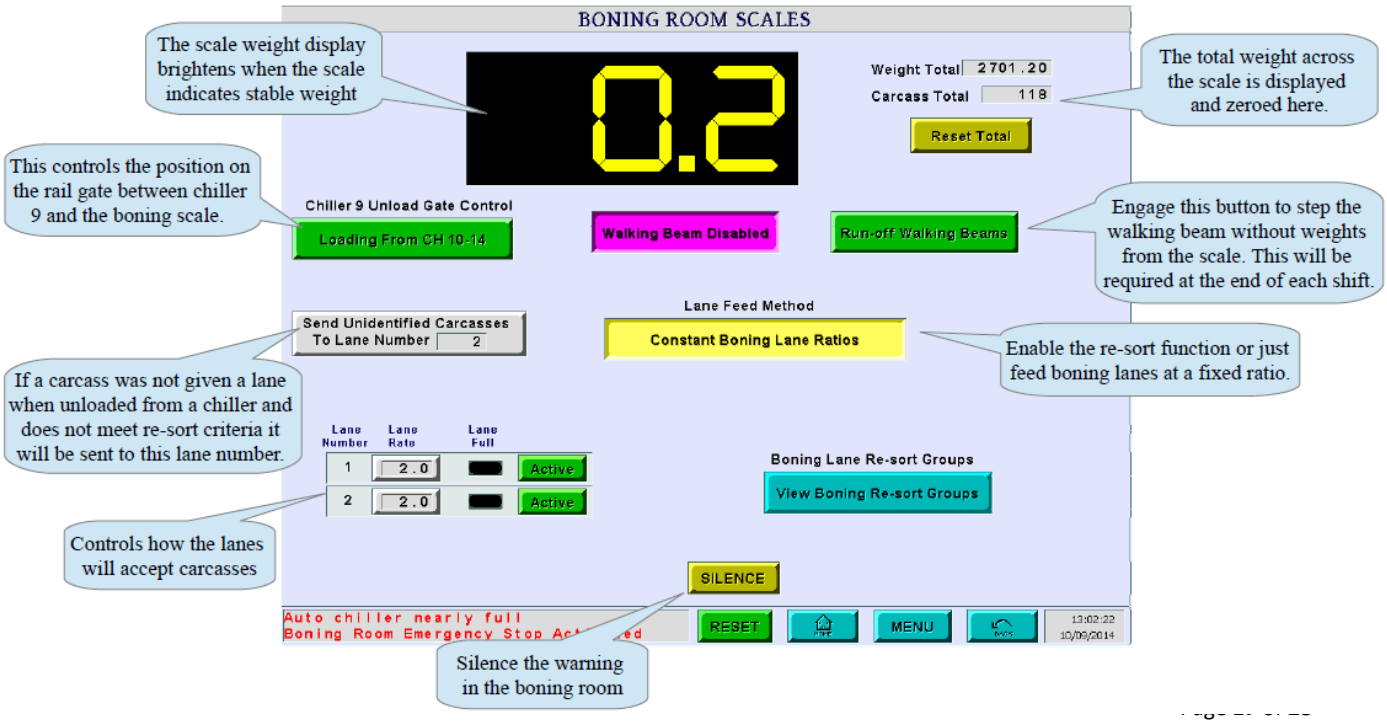
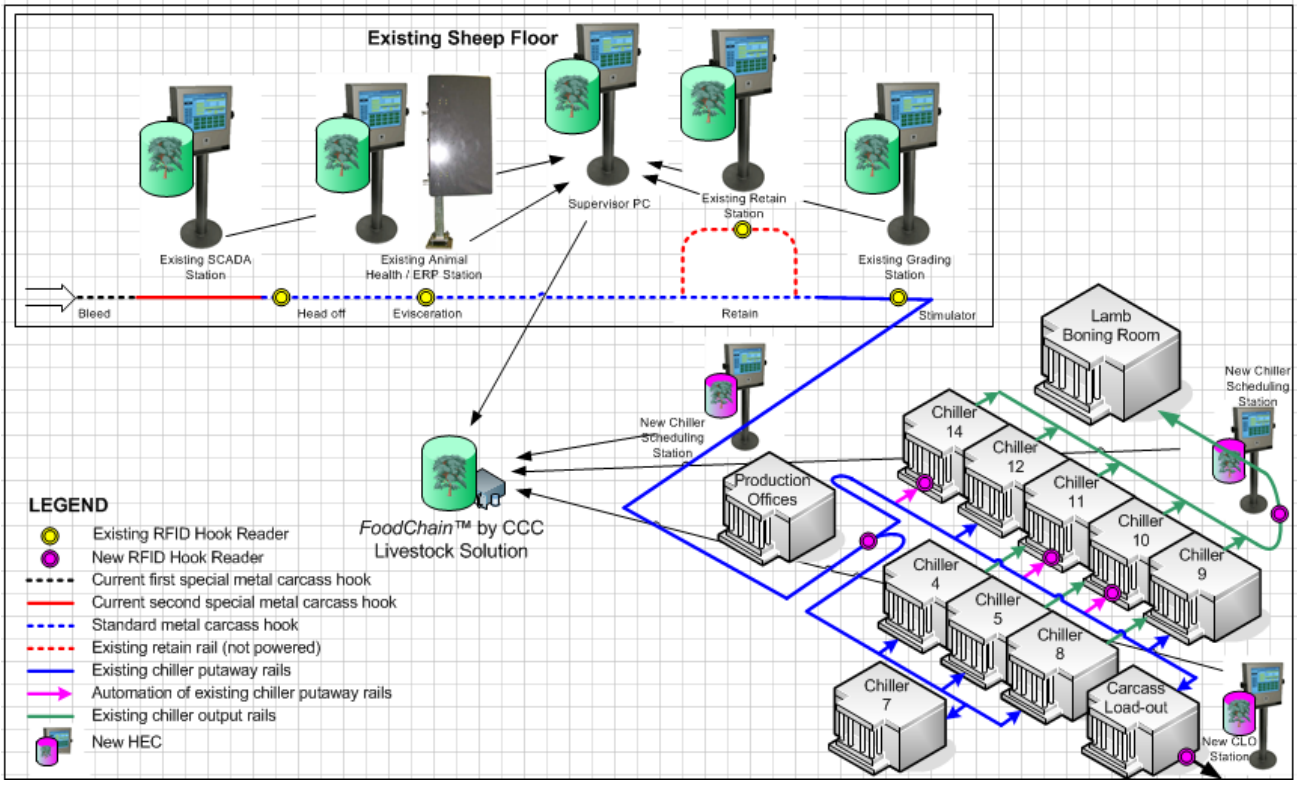


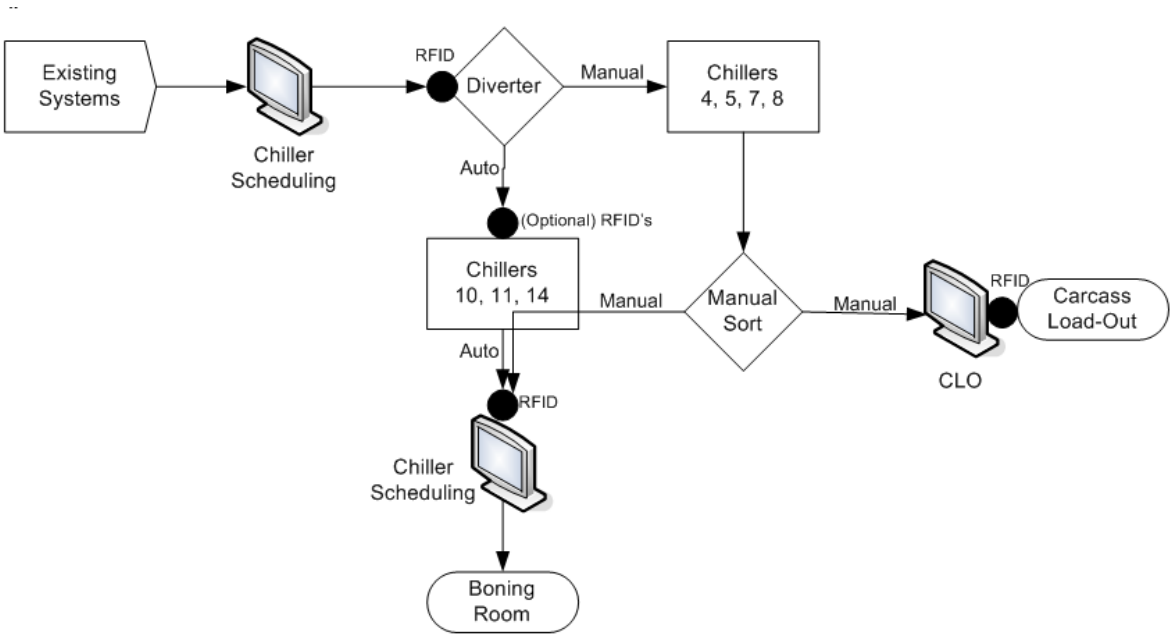
Figure J



5.1 Schematic and visual representation



High Level Process Flow



6 Microbiological Test Results

Following the installation of the automated chillers an independent laboratory performed a number of microbiological tests on selected products to determine any potential hygiene advantages of using automated chillers over manual handling of carcases. The testing was performed over two separate days and measured the APC[1] (Aerobic Plate Count) of boned products both from carcases that had been marshalled automatically (Unmanned) and carcases that had been manually marshalled into the Boning room.

[1]*The Aerobic Plate Count (APC) is used as an indicator of bacterial populations on a sample. The measure is cfu/g which is a unit used to estimate the number of viable bacteria or fungal cells in a sample*

Documented test reports revealed a significant drop in the APC for products boned from carcases that had been marshalled using the automated system. From the samples taken across both days the APC dropped by an average of 622,619 cfu/g per sample.

These results show there are significant hygiene benefits in using an automated chiller marshalling system for carcases.

[1]*The Aerobic Plate Count (APC) is used as an indicator of bacterial populations on a sample. The measure is cfu/g which is a unit used to estimate the number of viable bacteria or fungal cells in a sample*

7 Conclusions/recommendations

7.1 Recommendations

One of the most important lessons learnt was that it is imperative that the SCADA control system controls all areas of the chain including the chain speed. In the beginning there were some areas of the chain that were not managed by the SCADA system which compromised the integrity of the system as the SCADA system could not guarantee the position of the Carcase on the chain.

Consideration needs to be given to where Users will be operating the system and the location of the On-Floor Computers and whether or not the Users will be entering schedules from on the floor or off the floor.

The Reliability of pneumatics and sensors and the mechanical Operation of the system needs to be discussed thoroughly to select the most suitable equipment. Any mechanical failure of the system will compromise the integrity and accuracy of the system. Sourcing pneumatic and sensor equipment that can be readily available is recommended due to the heavy reliance on these parts throughout the process.

Careful consideration needs to be made on how the system will sort products into the chiller and whether or not they may need to be re-sorted again at the Boning Room in-feed based on a change in production schedules. The system will cater for this scenario. However the sort criteria does need to be setup correctly beforehand

A detailed Test plan needs to be prepared and adhered to during the testing phase. A record of test results and quantities tested needs to be recorded for reference.

An issues log should be kept up to date and reviewed to keep track of issues both mechanical and software.

Careful selection of the type of scale used at the Boning Room entry must be considered as this needs to be fast enough to process carcasses based on the speed of the chain. It is recommended to use an accumulation rail just prior to the Boning Room entry scale to deal with the occasional chain stoppage.

Using an independent Project Manager across all suppliers is recommended to alleviate any prejudice.

Summary

In Summary, while there have been several delays during the installation phase, there have been a number of lessons learnt and I do not expect similar delays for subsequent chillers. The software is largely tried and tested and new electrical parts (ie; sensors/switches, etc.) have been sourced to alleviate some of the electrical failures experienced While there are some minor mechanical issues to resolve they have largely been addressed and I would not expect similar issues to occur for subsequent chillers.

8 Appendix

Mechanical learnings

Despite solid planning we encountered a number of mechanical setbacks as we moved into production trials. These trials were very limited as the issue was usually found in the first ten minutes of commencing to fill our first automated chiller and with production continuing to follow the loading then resumed using manual labour. Below we provide some of the important observations and learnings made during our mechanical setup of the chillers.

1. Initially we found mechanical downfalls in the design of the in feed header chain. The problems were the length of the fingers that push the carcases to each gate, the drive motor having a sheer pin set up instead of a spring clutch, and the arms that pull the carcases onto each rail having a sprocket that was too small.

   We were able to fix some of these issues by putting a guide rail under the fingers for stability and upgrading the size of the sprockets on each rail so to drag the lambs around far enough for the T bar fingers to pick them up.

2. We also found that the wire proxy sensors were unreliable in the sense that the wires would move and not pick up every carcase that went onto each rail. We were able to change the type we use to a spring activated setup and is working much better. A problem we have had in all the chillers is the amount of swing that is created when the carcases drop into each chiller.

   We implemented a devise we call the "swing stopper" that when the carcases drop into the chiller they get to this device and it stops the swing so that the carcase don't swing out and fall behind the correct pusher.

   We have also put in a brake just before the swing stopper to reduce the speed the lambs coming into the chiller as we found this was a problem with rails 1 and 2 as the lambs would slide past their gate before it opened. Our chillers are on the other side of a firewall to the slaughter floor and we needed to rely on gravity to move lambs from one side to the other which resulted in the need for speed control.

3. We trialled using one air ram to advance each rail back and forth but it was inadequate so we added an extra ram to each rail.

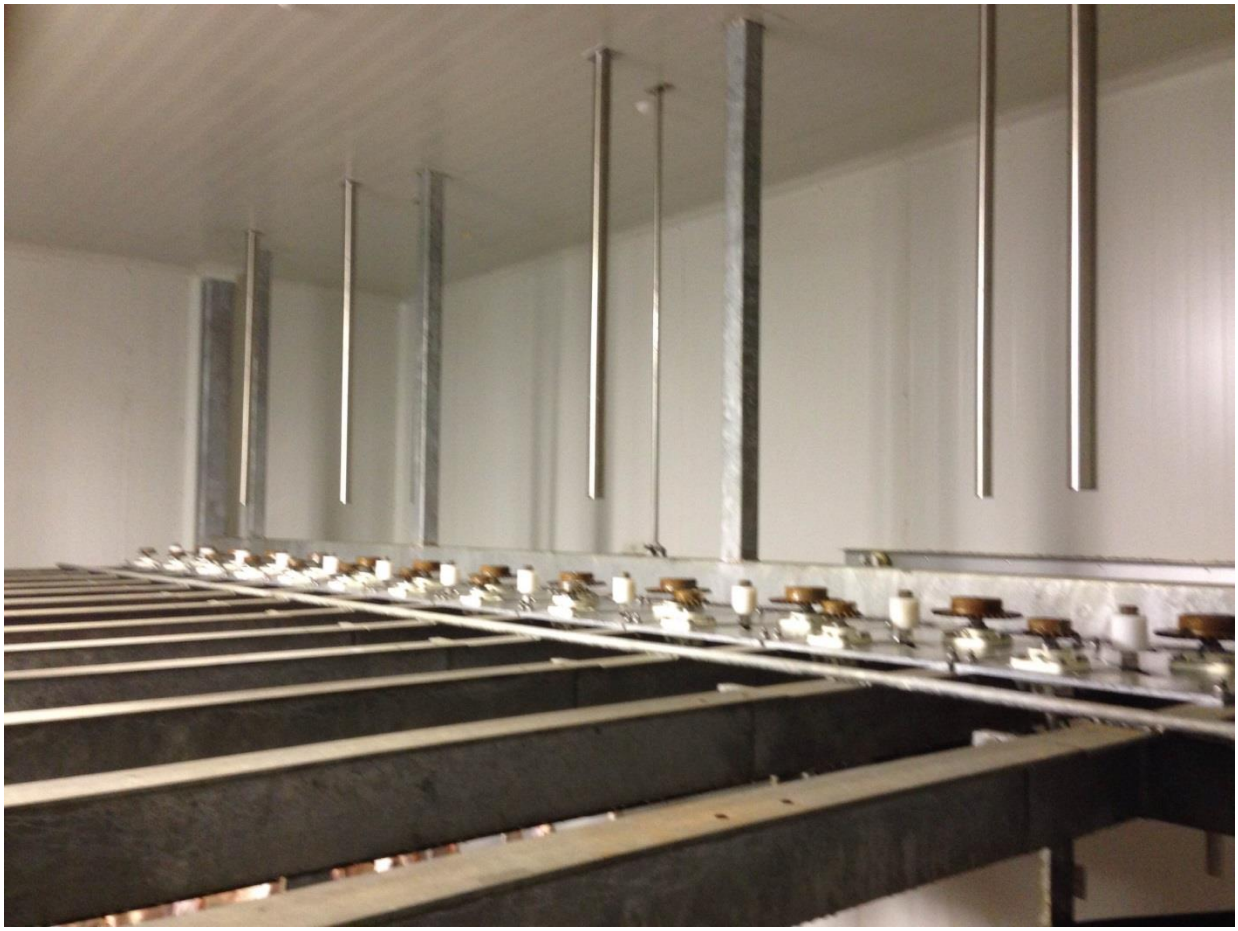
4. We found that the ram sensors were not able to handle the cold environment and we upgraded and siliconed them to the cylinders. We also had trouble with the sensor brackets on the rams that go through the doorway they would move the solution was to silicone them to the back side of the ram to stop movement.

Cylinder Frames and Indexers (Manufactured and Installed)

Pipe Droppers for air / electrics (Manufactured and Installed)

T-Bars Purchased for rails guides and pushers

Purchase of RAMS to move lambs down rails in both chillers

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