# FINAL REPORT

## IMPROVED TRACEABILITY AND QUALITY CONTROL FOR MEAT PRODUCTS USING RFID

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## 1.0 EXECUTIVE SUMMARY

The scope of this project was to investigate the feasibility of using UHF RFID technology in the meat processing industry to improve traceability and quality control for meat products.

An earlier study conducted in 2020, involved testing in a laboratory environment using a prototype RFID tunnel reader. Results were encouraging and lead to the current project which involved the design, build and commissioning of a production ready RFID Tunnel Reader.

A key benefit of RFID is its ability to read multiple RFID tags simultaneously, even where tags are attached to products/items enclosed in cardboard cartons, and irrespective of RFID tag orientation.

Although RFID systems that operate in the UHF band of frequencies are widely used, the performance of these systems can be diminished when the tagged products have a high-water content. This is the case when meat products are RFID labelled.

The objective of this project was to develop an RFID Tunnel Reader with high enough read accuracy to be valuable within the meat processing industry and improve traceability and quality control. RFID can automate quality control by counting primals and verifying SKUs to guarantee PROOF OF LOAD.

The commissioning and testing of the production ready RFID Tunnel reader station was performed at JBS from May 25 to May 27th, 2021.

Fourteen cuts of meat, including both beef and lamb were tested. The tests were designed to evaluate the differences in performance between different cuts, packing densities/configurations and species of product.

RAMP, with the support of the JBS, were able to test all 14 different products. The product mix included 9 SKUs of Lamb and 5 SKUs of Beef.

Each SKU was run through the RFID tunnel 20 times.

Of the 240 runs through the tunnel only one run was unsuccessful, and for this run only a single RFID tag was missed.

For this SKU, secondary testing was performed. RFID labels attached to each primal was orientated such that the RFID label directly faced an outside surface of the carton. The lower layer of primals had their labels faced to the bottom of the carton, whereas the top layer of primals had their labels facing upwards to the top of the carton. In this revised tag orientation 100% reads were recorded for the next sequential 20 runs. This was the only SKU, where change to the JBS Standard packing configuration was necessary.

The current results are very promising. The results suggest that the RFID Tunnel Reader Station developed by RAMP achieves exceedingly high RFID label tag read performance on the representative production product lines supplied by JBS.

RAMP recommends that the next phase of roll out of this technology should be the incorporation of the RFID Tunnel in an operational production line, where further verification of the solution over an extended time can be accomplished.

## 2.0 INTRODUCTION

JBS Australia is exploring the use of UHF RFID passive label tags on meat products throughout the meat processing phase to identify the quantity and SKU of meat present in each carton. UHF RFID technology has been proposed as a means of automating the verification process and eliminate sources of human error throughout the processing phase, particularly in relation to product identification and quantity checks.

RFID readers can read multiple RFID labels simultaneously, even when labelled product is packed inside cardboard boxes, where barcodes are hidden.

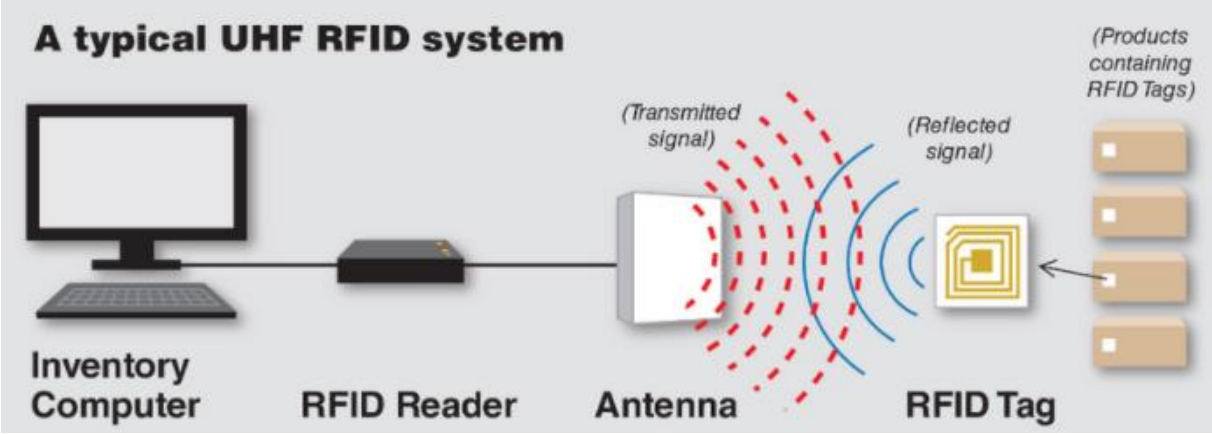


*Figure 1: A typical UHF RFID system*

RFID automates quality control by counting meat pieces and verifying SKUs to guarantee proof of load. RFID helps solve the significant problem of mislabeled meat.

Phase 1 of this project (2020-1013) verified that RFID technology could be used to achieve accurate and consistent reads of UHF tags attached to various SKUs of products provided by JBS Australia. As a result, a second phase of this project has been undertaken.

Phase 2 of the project is to trial software linking the carton label information to the RFID label numbers and description within the carton. This phase will allow the system to check if the contents in the carton do not match up and send a reject signal. Phase 2 testing includes but not limited to:

1. Incorrect products in carton
2. Incorrect quantity in carton (both testing too many and too few)
3. Mixing products (both correct and incorrect items in the carton)
4. Missing labels
5. Incorrect product labels applied

If any of the failure conditions are detected by the system a reject signal will be sent. For testing purposes, the reject signal can be represented by an indicator light.

Phase 3 aims to build upon techniques used in the first phase to show that the RFID technology can be applied within the production environment of JBS Australia to perform real-time validation/verification of packaged product during production. Phase 3 includes the:

1. Design of a RFID tunnel reader station suitable for use on a conveyor line at JBS Australia.
2. Build of a RFID tunnel reader station and testing it at RAMP premises.
3. Install of a RFID tunnel reader station and RFID printer at the JBS Australia site.
4. Trial of RFID label tags and an RFID tunnel reader station to accurately capture RFID encoded data, as product moves through the tunnel reader in cartons. The testing will demonstrate that the product SKUs and product quantities per cartons are captured. The testing will also demonstrate that the RFID Test Tunnel can operate in a “near” production environment.

## 3.0 PROJECT OBJECTIVES

Passive Radiofrequency Identification (RFID) solutions operating in the Ultra High Frequency (UHF) radiofrequency spectrum offer high speed, long range, RFID tag reading with extremely high read accuracy.

UHF RFID offers a good solution when identifying and tracking multiple items or assets moving through defined spaces. The items to be identified or tracked have adhesive RFID label tags applied to them, and when an RFID labelled product passes by, or through, an RFID reader station the digital encoded information identifying the unique product is captured wirelessly.

A key benefit of RFID is its ability to read multiple RFID tags simultaneously, even where tags are attached to products/items enclosed in cardboard cartons, and irrespective of RFID tag orientation.

Although RFID systems that operate in the UHF band of frequencies are widely used, the performance of these systems can be diminished when the tagged products have a high-water content. This is the case when meat products are RFID labelled.

The objective of this project is to evaluate the performance of UHF RFID antennas and RFID tags attached to meat products, with their potential application in providing real-time product identification and verification for use in downstream processes.

Objectives of this study are to:

1. Identify and document the main requirements for RFID viability on meat products.
    a. Identify geometric constraints (i.e., tag orientation, suitable tag size, carton dimensions and space availability) that may impact RFID performance.
    b. Identify environmental constraints (i.e., temperature, humidity, conveyor speed, other processes) that may influence the simulated production environment used for testing.
2. Evaluating the performance of UHF RFID technologies.
    a. Testing of UHF RFID technology on JBS product samples in *standard packing configurations* for each carton in the RFID tunnel.
    b. Testing of UHF RFID technology on JBS product samples in alternate packing configuration for each carton in the RFID tunnel to evaluate its performance against the *standard packed configuration*.
    c. Outline any process requirement changes that are necessary of JBS Australia to achieve statistically significate read rate performance for the provided JBS product samples.
3. Outline additional phases based on the recommendations of the study.

## 4.0 DESIGN & BUILD OF RFID TUNNEL READER STATION

The design and build stage of the project involved the procurement of both mechanical and electronic parts and subsequent assembly and integration of them.

The key elements of the system include:

1. A food grade stainless steel, motorized conveyor bed with adjustable speed control.
2. A stainless-steel tunnel structure internally lined with perspex.
3. RF shielding curtains at the front entrance and rear exit of the tunnel structure.
4. Top and bottom mounted RFID antennas and fixing mechanisms to allow antenna position adjustment.
5. Electronics enclosure to house the RFID reader electronics, power supply, computer, and display.
6. Photoelectric sensors at the tunnel entry and exit locations to control RFID reader operation.

The concept drawings below show some of these elements.

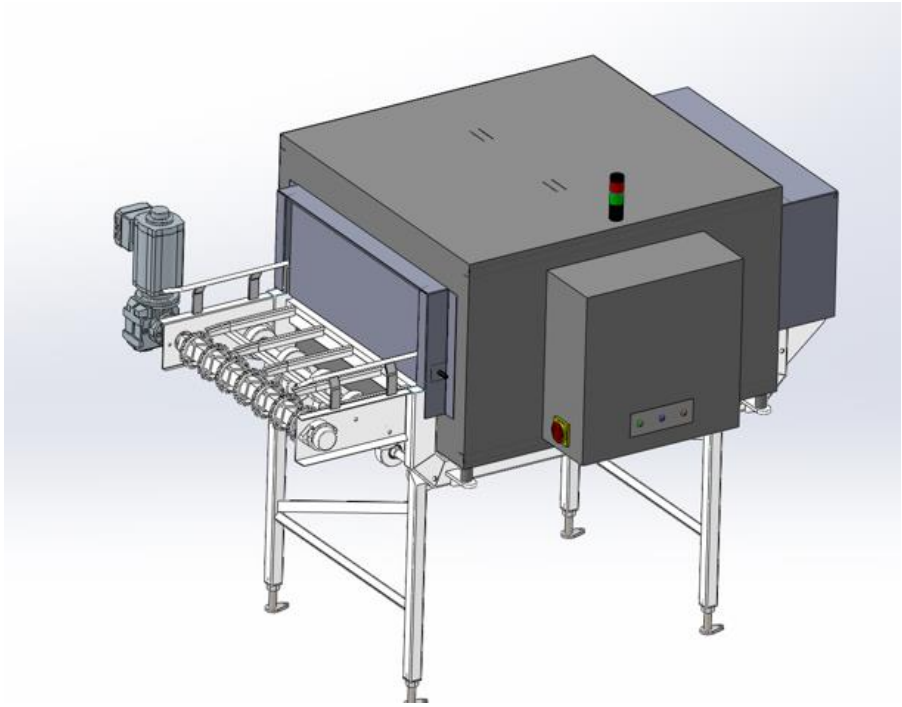

*Figure 2: Concept drawing showing overall assembly of the RFID Tunnel system*

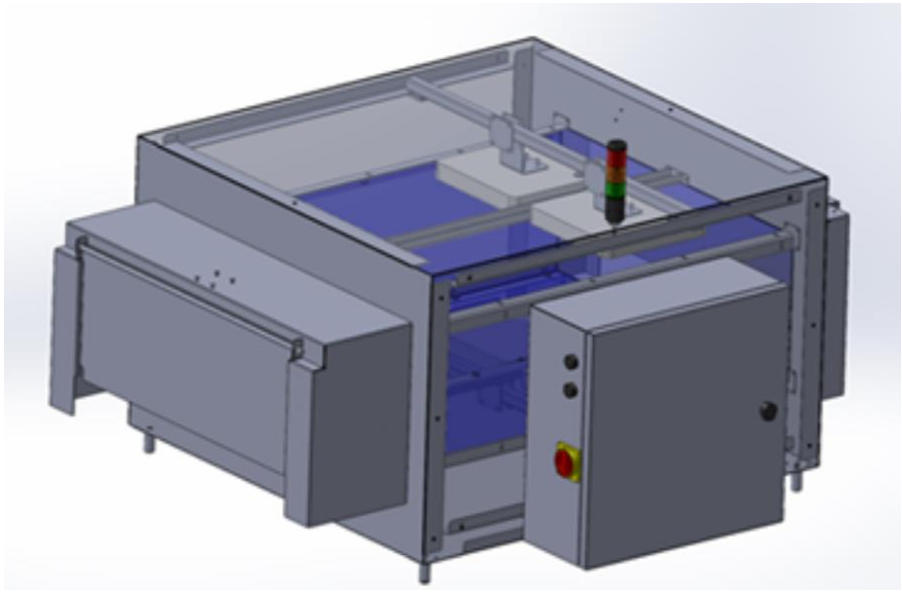

*Figure 3: Concept drawing showing internal RFID antennas within the RFID Tunnel.*

The following photographs document the "as-built" RFID Tunnel System. Photographs of the assembled unit as well as pictures of relevant subassemblies are presented.

*Figure 4: RFID Tunnel Entry*

*Figure 5: RFID Tunnel and conveyor – side view – Tunnel cover panel removed*.

*Figure 6: RFID Tunnel and conveyor – rear exit view – Tunnel cover panel removed.*

*Figure 7: RFID Tunnel and conveyor – Electronics cabinet and display*

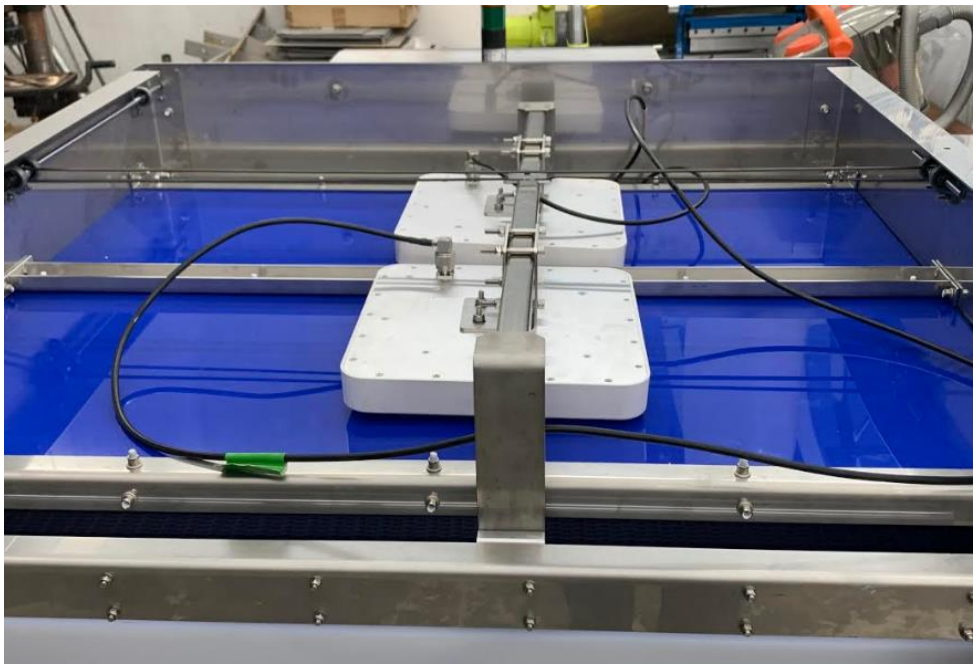

*Figure 8: RFID Tunnel and conveyor – RFID Antennas and adjustment mechanism*

*Figure 9: RFID Tunnel and conveyor – RF Shielding Curtain*

*Figure 10: RFID Tunnel and conveyor – User display and light stack*

## 5.0 COMMISSIONING & TESTING OF RFID TUNNEL READ STATION

The commissioning and testing of the RFID Tunnel reader station was performed from May 25th to May 27th, 2021.

Tests were conducted to fine tune and evaluate the performance of an RFID Tunnel at reading RFID tagged product passing through the tunnel on a "near" production environment.

14 cuts of meat, including both beef and lamb were tested. The tests were designed to evaluate the differences in performance between different cuts, packing densities/configurations and species of product.

The RFID tunnel reader was evaluated not only for its ability to read the RFID tagged product passing through the tunnel, but also its ability to contain the RF field so as not to "over read" tags from nearby product, not passing through the tunnel.

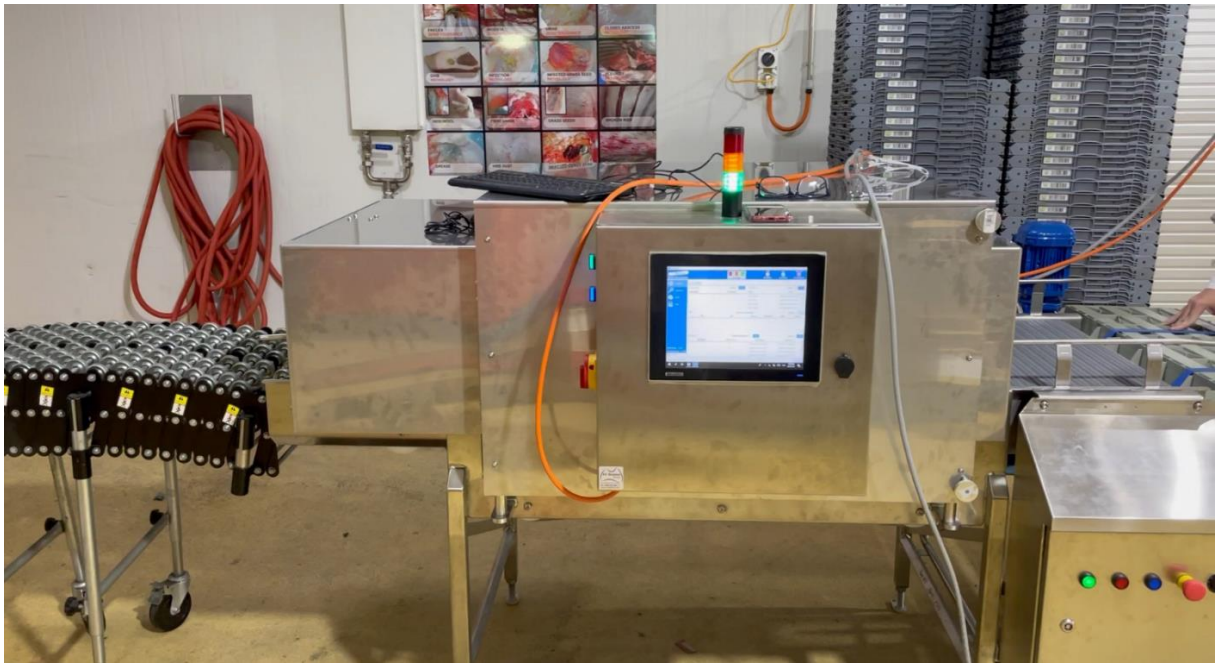

*Figure 11: Installed RFID Tunnel and conveyor – side view*

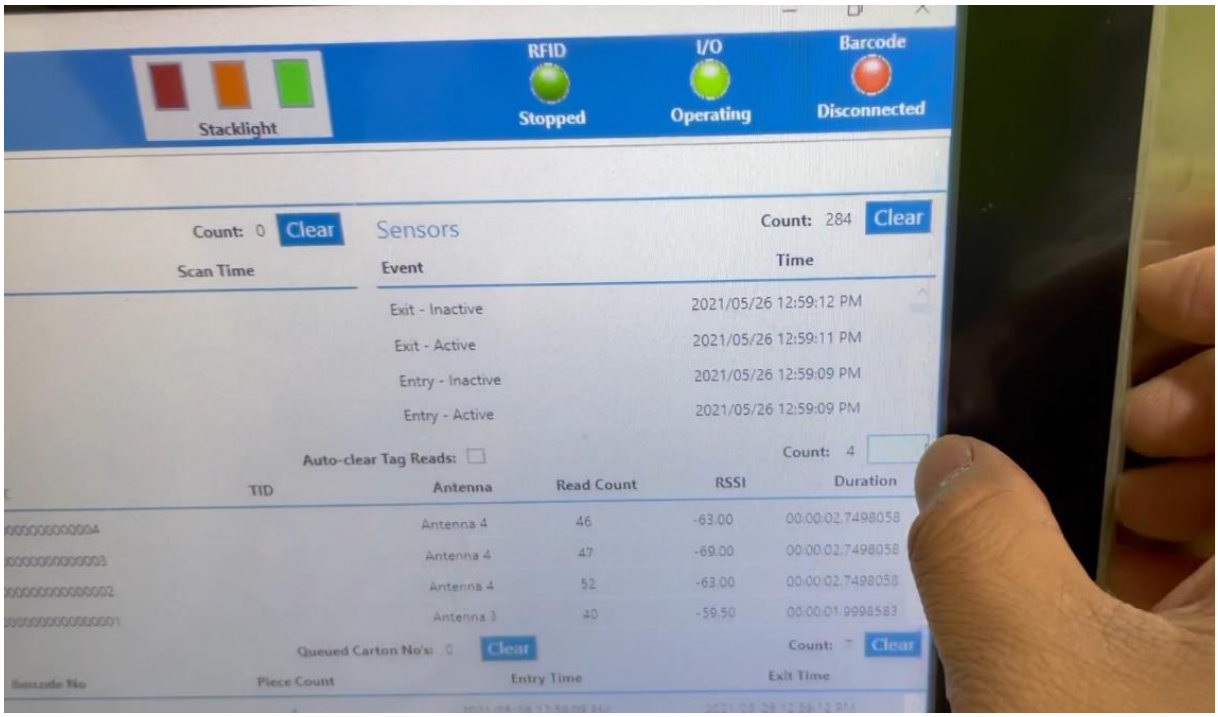


*Figure 12: RFID Tunnel and conveyor –Control screen*

*Figure 13: RFID Tunnel and conveyor – RF Shielding Curtain and exit*

## 6.0 TESTING METHODOLOGY

Testing was split into 3 key areas. Tests were performed to:

1. Optimize RFID Tunnel performance.
2. Measured the accuracy of RFID Tunnel in its ability to correctly count tagged meat pieces within a given carton for different meat cuts. To do this, various scenarios will be tested including but not limited to:
    - Missing tag i.e., in a carton of 8 one product is not tagged, should only show 7 products
    - Too many or not enough products in a carton
    - Missing carton label
    - Incorrect products in a carton/ Products wrongly labelled
    - Mix of correct and incorrect items in a carton

3. Evaluate the ability of the RFID Tunnel to contain the RF field to avoid tag "over reads" from Tags in proximity to the tunnel. This will prescribe the minimum carton spacing acceptable on the line as product enters the RFID Tunnel as well as any required zone around the tunnel where RFID Tags need to be excluded.

### 6.1 Optimize RFID Tunnel Performance

There are a range of parameters which impact RFID read performance. These include:

- Reader RF transmit power.
- Reader RF receive sensitivity.
- Reader communication protocol selection.
- Dwell time within the RFID Tunnel, governed by the conveyor speed.
- Positioning of the RFID antennas within the RFID Tunnel.
- Selection of the RFID tag type, size, label material type.
- Tag placement geometry within the carton under test.
- Tag orientation.

RAMP prior to arrival at the JBS Australia facility, conducted tests to investigate each of the above parameters and selected the settings, adjustments, RFID label, and tag placement geometry to optimize RFID read performance.

Once on site at JBS, RAMP assembled the RFID tunnel and using the optimized parameters selected by RAMP began the test program.

### 6.2 Measure RFID Tunnel read accuracy for various product types.

With the RFID tunnel configuration settings fixed, RAMP conducted testing on various product types. Both Lamb and Beef products were tested.

JBS provided the following products for testing:

- 82703 Lamb Shdr rack Multi Wrapped (36 pieces, 18 RFID tags).


*Figure 14: 82703 Carton label*

*Figure 15: RFID Tagged Product*

- 83513 Lamb Shank Layer Pack (Single RFID Tag)


*Figure 16: 83513 Carton label*

*Figure 17: Untagged Product*

*Figure 18: RFID Tagged Product*

- 84015 Lamb Bones Bulk Pack (Single tag)


*Figure 19: 84015 Carton Label*

*Figure 20: Untagged Product*

*Figure 21: RFID Tagged Product*

- 87939 Lamb Leg Ch-off Individually Wrapped Vacuum sealed (6 pieces, 6 RFID Tags)


*Figure 22: 87939 Carton Label*

*Figure 23: Untagged Product*

*Figure 24: Bottom Layer, RFID Tags facing down.*

*Figure 25: Top Layer, RFID Tags facing up.*

- 88601 Lamb Breast Bulk Pack


*Figure 26: 88601 Carton Label*

*Figure 27: Untagged Product*

*Figure 28: RFID Tagged Product*

- 88675 Lamb Leg Bones Bulk Pack (1 RFID Tag)


*Figure 29: 88675 Carton Label*

*Figure 30: Untagged Product*


*Figure 31: RFID Tagged Product*

- 87936 Lamb Shoulder BRN oyster Individually Wrapped Vacuum sealed (12 pieces, 12 RFID Tags)


*Figure 32: 87936 Carton Label*


*Figure 33: Example RFID Tag Label*

- 87931 Lamb Rack Individually Wrapped/Vacuum sealed (20 pieces, 20 RFID Tags)


*Figure 34: 87931 Carton Label*


*Figure 35: Tagged Product*

- 85021 L Neck Layer Pack (1 RFID Tag)


*Figure 36: 85021 Carton label*

*Figure 37: Untagged Product*

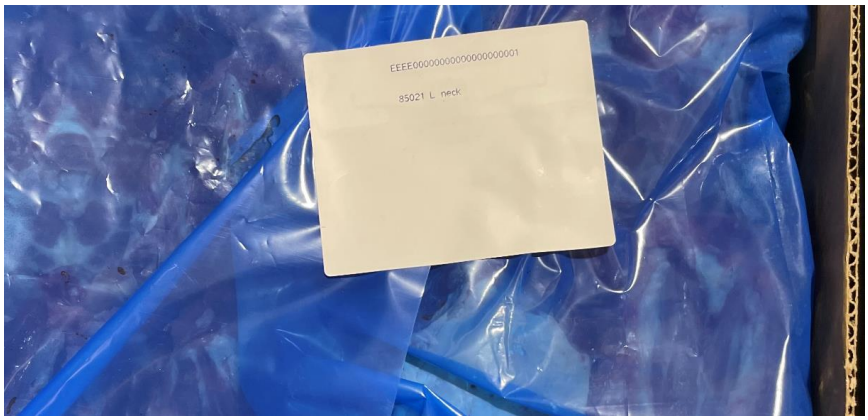


*Figure 38: RFID Tagged Product*

- 71497 Beef STL Individually Wrapped / Vacuum sealed (4 Pieces, 4 RFID Labels)


*Figure 39: 71497 Carton Label*

*Figure 40: Untagged Product*


*Figure 41: Example RFID Tag Label*

*Figure 42: RFID Tag arrangement in Carton*

- 72617 Beef Eye Round Individually Wrapped/ Vacuum sealed (8 pieces, 8 RFID Labels)


*Figure 43: 72617 Carton label*

*Figure 44: Untagged Product*

*Figure 45: Bottom Layer RFID Tags*

*Figure 46: Top Layer RFID Tags*

- 73433 Beef NE Brisket Individual Wrapped/ Vacuum sealed (3 pieces, 3 RFID tags)


*Figure 47: 73433 Carton Label*


*Figure 48: Untagged Product*

*Figure 49: Bottom Layer RFID Tag*

*Figure 50: Middle Layer RFID Tag*

*Figure 51: Top Layer RFID Tag*

- 76913 Beef Short ribs MW/ Vacuum sealed (8 pieces, 8 RFID tags)


*Figure 52: 76913 Carton label*

*Figure 53: Untagged pieces*

*Figure 54: RFID Tagged Labels*

- 76976 Beef Spareribs, Layer Pack, (1 RFID Tag)


*Figure 55: 76976 Carton Label*

*Figure 56: Untagged Product*

RAMP performed the following Test Procedure for each sample carton.

1. Counted the number of individual meat packs that comprise the carton.
2. Recorded the number.
3. Photographed the packaging geometry, so that the same arrangement of meat packs could be used consistently through the test program.
4. Printed RFID labels with data encoding identifying the SKU of the meat type and a serial number from 1….. n, for the number of tags to be placed in the box. The RFID Tag inlay selected was a synthetic RFID label 100mm x 80mm with an Avery Dennison inlay (product code: 3007789) customised for use directly on meat.

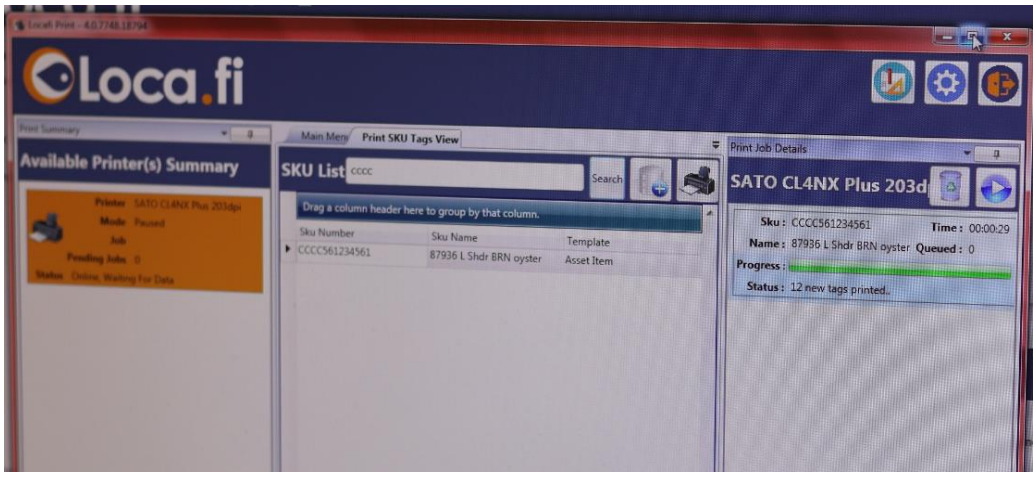


*Figure 57: RAMP RFID Printer software interface*

*Figure 58: RFID Label Printer generating encoded Tag.*

5. Applied the RFID tags to the meat packs. Generated a planogram of the RFID tag locations within the box.

*Figure 59: RFID Tag applied to Product.*

6. Used a consistent box orientation to feed the cartons into the RFID Tunnel. Cartons were fed into the RFID Tunnel with the leading edge of the carton being the long face.
7. Set the tunnel conveyor speed to 0.5 metres per second. Given the length of the tunnel is 1 metre, each carton was within the tunnel for approximately 2 seconds.
8. Set the Tunnel reader power level to 30dBM.
9. Configured the RFID Tunnel to operate using a Tag Suppression mode. This Reader setting and RAMP custom software, triggered by the entry and exit IR sensors, was used to control the RFID Reader.
10. Recorded the number of RFID tag reads. (Including under reads and over-reads)

Auto-clear Tag Reads: ☐ Count: 4 Clear

| EPC | TID | Antenna | Read Count | RSSI | Duration |
|---|---|---|---|---|---|
| 00000000000000001 | | Antenna 3 | 105 | -44.00 | 00:00:02.8435004 |
| 00000000000000003 | | Antenna 4 | 67 | -64.00 | 00:00:03.2497214 |
| 00000000000000002 | | Antenna 3 | 44 | -60.50 | 00:00:04.5153114 |
| 00000000000000026 | | Antenna 3 | 2 | -66.50 | 00:00:00 |

*Figure 60: RFID Tunnel Reader Display showign count of 4 Tags*

11. Repeated step 6 to 10, 20 times, to create 20 consecutive test runs.

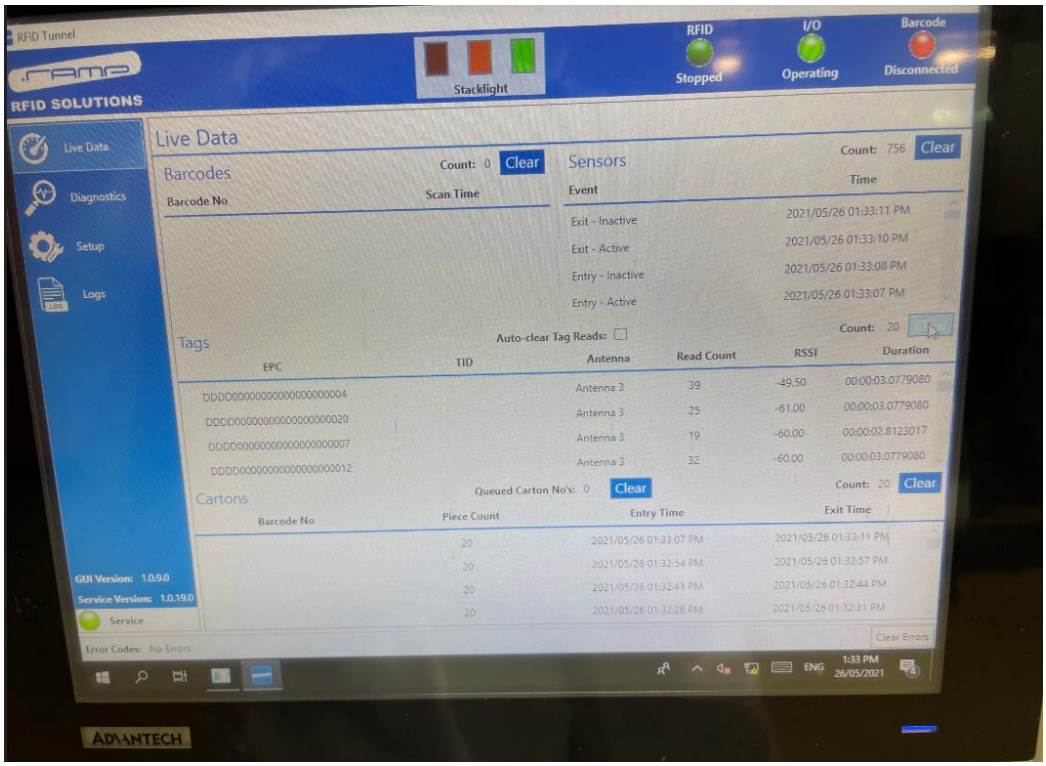


*Figure 61: RFID Tunnel Reader Operator Display*

12. From the collected data recorded:
    a. The number of over reads (if any).
    b. The average tag read performance over the full 20 runs (% read).
    c. The % of cartons that would be incorrectly rejected based on the 20 runs.

Once the data above had been collected for each product type, a ranking list was generated to identify easily read product from more difficult to read product.

Difficult to read product was set aside for more testing to be conducted.

For difficult to read meat types, additional data was collected.

Only one SKU, the 87936 Lamb Shoulder BRN oyster (Individually Wrapped Vacuum sealed, 12 pieces, 12 RFID Tags) proved difficult to read.

For this product, using the same procedure as above, the 87936 carton was retested. However, for next 20 Runs, RFID labels were rotated/repositioned within the box to what was expected as preferred orientations. The new RFID label orientations were noted, and 20 test runs were conducted. The results were then compared to the initial testing results.

## 6.3 Measure the RFID tag exclusion zone around the Tunnel Reader station

The objective of the following test was to evaluate the ability of the RFID Tunnel to contain the RF field to avoid tag “over reads” from Tags in proximity to the tunnel.

Given the entry and exit apertures of the RFID Tunnel, RAMP expected that the RF field generated within the tunnel would radiate outside of the tunnel. To mitigate this effect RF blocking/shielding curtain material was placed at the tunnel entry and exit. The RF curtain was pushed up over an entering carton and then flapped down once the carton passes through the entry. The same occurs at the exit.

Despite the RF blocking flaps, RAMP still expected to observe some RF field leakage.

The risk of such RF field leakage on the performance of the RFID tunnel, is that rogue RFID tag reads “over reads” may be captured by the external radiating RF field and would be interpreted as items within the carton present within the RFID Reader Tunnel at the time. The rogue tags would thus jeopardize the accuracy of the reader station and result in incorrectly rejected cartons.

By quantifying the zone around the RFID Tunnel where RF leakage occurs a prescribed minimum carton spacing acceptable on a production line can be defined.

Testing was performed using the following methodology.

1. Various cartons of RFID labelled product were placed in proximity to the RFID Tunnel.
2. The RFID tunnel was activated, and any RFID reads noted.
3. For any RFID reads observed the distance of the carton to the RFID Tunnel was recorded.

The testing established the feasibility of having RFID labels in the proximity of the RFID Tunnel.

# 7.0 TEST RESULTS

## 7.1 RFID Tunnel Setting Adopted to Optimize Performance

The following RFID system parameters were selected to optimize system performance.

- Reader RF transmit power: 30dBM.
- Reader RF receive sensitivity: maximum.
- Reader communication protocol selection: Tag suppression mode
- Dwell time within the RFID Tunnel: 2 seconds
- Positioning of the RFID antennas within the RFID Tunnel: 2 above, 2 below.
- Selection of the RFID tag type, size, label material type: Synthetic RFID label 100mm x 80mm with an Avery Dennison inlay (product code: 3007789) customised for use directly on meat.
- Tag placement geometry within the carton under test: JBS Standard packing configuration.

In all the tests performed, it was ensured that no RFID label tags were in direct contact with one another, thus preventing RF detuning. RAMP recommends that all tag orientations adopted by JBS moving forward, avoid having tag-on-tag placement, as this will hamper tag read performance overall.

## 7.2 Measure RFID Tunnel read accuracy for various product types.

RAMP conducted testing on various product types. Both Lamb and Beef products were tested.
Each SKU carton was provided by JBS Australia in their in the standard packing configuration.

Five Beef SKUs and nine Lamb SKUs were provided for testing. Each sample carton was run through the RFID Tunnel Reader 20 times sequentially. For each run, the number of RFID tags were recorded and compared to the expected number of tags for each carton.

A summary of the test results for each SKU are presented below. The full set of test results, planograms and carton packaged photos are attached in Appendix A.

**1. Beef Navel End Brisket,** Individually Wrapped, Vacuum Sealed

RFID Product number 1111, JBS SKU Number 73433

Carton Piece Quantity: 3, RFID Tag Quantity: 3 **Result from 20 runs: 100% tag reads**

**2. Beef STL,** Individually Wrapped/Vacuum Sealed

RFID Product number 2222, JBS SKU Number 71497

Carton Piece Quantity: 4, RFID Tag Quantity: 4 **Result from 20 runs: 100% tag reads**

**3. Beef Eye Round,** Individually Wrapped, Vacuum Sealed

RFID Product number 3333, JBS SKU Number 72617

Carton Piece Quantity: 8, RFID Tag Quantity: 8 **Result from 20 runs: 100% tag reads**

**4. Beef short ribs,** Multi-wrapped, Vacuum Sealed.

RFID Product number 4444, JBS SKU Number 76913

Carton Piece Quantity: 4, RFID Tag Quantity: 4 **Result from 20 runs: 100% tag reads**

**5. Beef Spareribs,** Layer Pack

RFID Product number 5555, JBS SKU Number 76976

Carton Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

**6. Lamb Shoulder R,** Multipack, Wrapped

RFID Product number 6666, JBS SKU Number 82703

Carton Piece Quantity: 36, RFID Tag Quantity: 18 **Result from 20 runs: 100% tag reads**

**7. Lamb Shank,** layer pack

RFID Product number 7777, JBS SKU Number 83513

Carton Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

**8. Lamb Bones,** Bulk Pack

RFID Product number 8888, JBS SKU Number 84015

Carton Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

**9. Lamb Leg Ch-off,** Individually Wrapped, Vacuum Sealed

RFID Product number 9999, JBS SKU Number 87939

Carton Piece Quantity 6, RFID Tag Quantity 6 **Result from 20 runs: 100% tag reads**

**10. Lamb Breast,** Bulk Pack

RFID Product number AAAA, JBS SKU Number 88601

Carton Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

**11. Lamb Leg Bones,** Bulk pack

RFID Product number BBBB, JBS SKU Number 88675

Carton Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

**12. Lamb Shoulder BRN Oyster,** Individually Wrapped, Vacuum Sealed

RFID Product number CCCC, JBS SKU Number 87936

Carton Piece Quantity: 12, RFID Tag Quantity: 12

Result from 19 runs: 100% tag reads from 1 run: 1 of 12 Tags not read.

**Result from 20 runs: 99.58% tag reads**

| Run | CCCC01 | CCCC02 | CCCC03 | CCCC04 | CCCC05 | CCCC06 | CCCC07 | CCCC08 | CCCC09 | CCCC10 | CCCC11 | CCCC12 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 11 | 91.67 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |

*Figure 63: Results of SKU Number 87936 for 20 runs through the RFID Tunnel*


*Figure 63: Results of SKU Number 87936 for 20 runs through the RFID Tunnel*

For this SKU, secondary testing was performed. RFID labels attached to each primal was orientated such that the RFID label directly faced an outside surface of the carton. The lower layer of primals had their labels faced to the bottom of the carton, whereas the top layer of primals had their labels facing upwards to the top of the carton. In this revised tag orientation 100% reads were recorded for the next sequential 20 runs. This was the only SKU, where change to the JBS Standard packing configuration was necessary.

**13. Lamb Rack,** individually wrapped, vacuum sealed.

RFID Product number DDDD, JBS SKU Number 87931

Carton Piece Quantity: 20, RFID Tag Quantity 20 **Result from 20 runs: 100% tag reads**

**14. Lamb Neck,** Layer Pack

RFID Product number EEEE, JBS SKU Number 85021

Carton Piece Quantity: Multiple, RFID Tag Quantity 1 **Result from 20 runs: 100% tag reads**

## 7.3 Measure the RFID tag exclusion zone around the Tunnel Reader station

JBS advised that the maximum carton throughput was typically 14 cartons per minute. For equally spaced cartons, this equates to a leading edge of a carton entering the RFID tunnel reader every approximately 4 seconds. At a conveyor speed of 0.5 metres per second, this equates to a separation of 2 metres, leading edge to leading edge. Using this logic, RAMP assumed that the closest that 2 boxes could be, would be approximately 2 metres.

The RFID tunnel is 1 metre and therefore the absolute minimum clear separation between two cartons will be 1 metre, as only a single carton can be within the RFID tunnel at any given time. At this minimum distance, as one carton leaves the tunnel, its following carton is directly in front of the RF curtain at the entry of the tunnel.

RAMP testing concluded that for most meat products, where RFID tags are attached to the meat pieces (tags in close contact with meat) no stray tags were read even when a carton was directly in front of the RF curtain at the entry of the tunnel.

An exception to this were cartons where a single RFID tag was applied to an external plastic bag, effectively just floating in air. This is the case typically for Bulk Packs. RFID tags "in air" will read better than RFID tags in contact with meat. For this population of cartons, RAMP observed stray reads within the tunnel when these cartons were directly in front of the RF curtain at the entry of the tunnel. In these cases, when the cartons were positioned 1 metre upstream of the front entry of the Tunnel reader, no stray reads were observed. This 1 metre upstream combined with the 1 metre length of the tunnel results in a 2-metre separation between cartons.

The diagram below, illustrates the recommended carton separation and shows the required installation length of 2m, necessary to commission the RFID Tunnel Reader station.

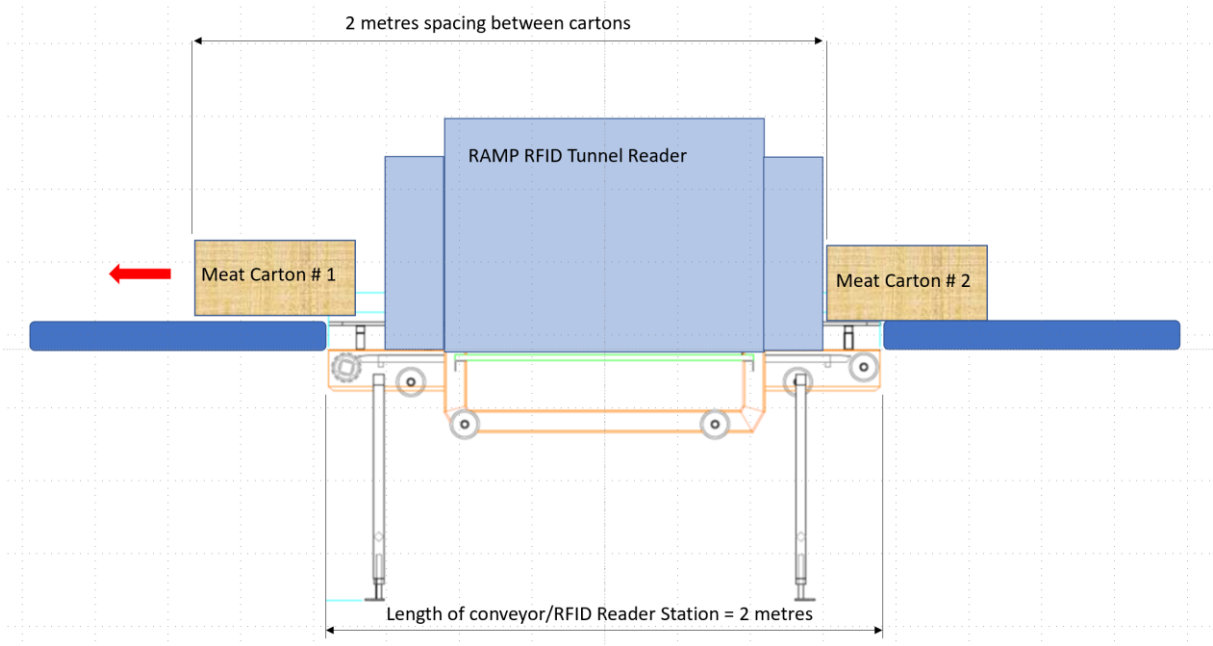


*Figure 65: Carton recommended separation & RFID Tunnel installation space required.*

## 8.0 DISCUSSION

RAMP, with the support of the JBS, were able to test all 14 different products selected by JBS. The product mix included 9 SKUs of Lamb and 5 SKUs of Beef.

Each SKU was run through the RFID tunnel 20 times.

Of the selected SKU, 13 product types where 100% successfully read for all 20 runs through the RFID Tunnel. Only one product type, the Lamb Shoulder BRN oyster cut (box of 12) failed to read for all 20 RFID tunnel runs. For this product only one of the runs through the tunnel was unsuccessful, and for this run only a single RFID tag was missed. For this SKU, the performance achieved was 99.58%.

The testing suggests that a false carton rejection of this difficult SKU may be expected once in 20 cartons, but with the mix of all SKU, the data suggests a false carton rejection may happen as infrequently as once in 280 cartons being processes through the tunnel.

Further testing of the problematic SKU, the Lamb Shoulder BRN oyster cut (box of 12) demonstrated 100% reading on a further 20 runs. This improved result was achieved by changing from the JBS Standard packing configuration of this SKU, such that all RFID label tags are orientated so they directly face an outer carton face within the box.

Testing for stray reads was also done with cartons of individually RFID tagged meat pieces, placed up close to the RF entry tunnel curtain while another carton was going through the tunnel. No tags were read. Similar test was also performed with a box of tagged meat near the exit of the tunnel, also no stray tags were read.

However, when it came to Layer Packed meat (1 big bag full of meat) where the RFID label tag was not in direct contact with the meat. The RFID Label was just applied to the plastic bag and effectively just floating. This caused occasional stray reads.

Testing confirmed that for cartons 2 meters apart, no stray reads were observed. The size of this exclusion zone is approximately 1 metre outwards from the entry and exit points for all SKUs tested.

The size of this exclusion zone is approximately 1 metre outwards from the entry and exit points for all SKUs tested.

## 9.0 CONCLUSIONS/ RECOMMENDATIONS

The current results are very promising. The results suggest that the RFID Tunnel Reader Station developed by RAMP achieves exceedingly high RFID label tag read performance on the representative production product lines supplied by JBS Australia.

RAMP recommends that the next phase of roll out of this technology should be the incorporation of the RFID Tunnel in an operational production line, where further verification of the solution over an extended time can be accomplished.

# 10.0 APPENDICES

## 10.1 Appendix A – RFID Read Performance Test Results

*10.1.1 Beef Navel End Brisket, Individually Wrapped, Vacuum Sealed*

RFID Product number 1111, SKU Number 73433

Piece Quantity: 3, RFID Tag Quantity: 3 **Result from 20 runs: 100% tag reads**

| Run | 111101 | 111102 | 111103 | Tags Read | Tags Read % |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 3 | 100.00 |
| 2 | 1 | 1 | 1 | 3 | 100.00 |
| 3 | 1 | 1 | 1 | 3 | 100.00 |
| 4 | 1 | 1 | 1 | 3 | 100.00 |
| 5 | 1 | 1 | 1 | 3 | 100.00 |
| 6 | 1 | 1 | 1 | 3 | 100.00 |
| 7 | 1 | 1 | 1 | 3 | 100.00 |
| 8 | 1 | 1 | 1 | 3 | 100.00 |
| 9 | 1 | 1 | 1 | 3 | 100.00 |
| 10 | 1 | 1 | 1 | 3 | 100.00 |
| 11 | 1 | 1 | 1 | 3 | 100.00 |
| 12 | 1 | 1 | 1 | 3 | 100.00 |
| 13 | 1 | 1 | 1 | 3 | 100.00 |
| 14 | 1 | 1 | 1 | 3 | 100.00 |
| 15 | 1 | 1 | 1 | 3 | 100.00 |
| 16 | 1 | 1 | 1 | 3 | 100.00 |
| 17 | 1 | 1 | 1 | 3 | 100.00 |
| 18 | 1 | 1 | 1 | 3 | 100.00 |
| 19 | 1 | 1 | 1 | 3 | 100.00 |
| 20 | 1 | 1 | 1 | 3 | 100.00 |

PLANOGRAPH
TOP VIEW

| |
|---|
| 111101 |
| 111102 |
| 111103 |

### *10.1.2 Beef STL Individually Wrapped/Vacuum Sealed*

RFID Product number 2222, SKU Number 71497

Piece Quantity: 4, RFID Tag Quantity: 4 **Result from 20 runs: 100% tag reads**

| Run | 222201 | 222202 | 222203 | 222204 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 4 | 100.00 |

PLANOGRAPH

TOP VIEW

| 1 | 2 | 3 | 4 |
|---|---|---|---|

### *10.1.3 Beef Eye Round, Individually Wrapped, Vacuum sealed*

RFID Product number 3333, SKU Number 72617

Piece Quantity: 8, RFID Tag Quantity: 8 **Result from 20 runs: 100% tag reads**

| Run | 333301 | 333302 | 333303 | 333304 | 333305 | 333306 | 333307 | 333308 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 100.00 |

PLANOGRAPH

Side View

| | | | |
|---|---|---|---|
| 8 | 7 | 6 | 5 |
| 1 | 2 | 3 | 4 |

*10.1.4 Beef short ribs, Multi-wrapped, Vacuum sealed.*
RFID Product number 4444, SKU Number 76913

Piece Quantity: 4, RFID Tag Quantity: 4 **Result from 20 runs: 100% tag reads**

| Run | 444401 | 444402 | 444403 | 444404 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 4 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 4 | 100.00 |

PLANOGRAPH
SIDE VIEW

| | |
|---|---|
| 3 | 1 |
| 4 | 2 |

### *10.1.5 Beef Spareribs, Layer Pack*

RFID Product number 5555, SKU Number 76976

Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

| Run | 555501 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

| PLANOGRAPH |
|---|
| TOP View |
| 1 |

### *10.1.6 Lamb Shoulder R, Multipack, Wrapped*

RFID Product number 6666, SKU Number 82703

Piece Quantity: 36, RFID Tag Quantity: 18 **Result from 20 runs: 100% tag reads**

| Run | 666601 | 666602 | 666603 | 666604 | 666605 | 666606 | 666607 | 666608 | 666609 | 666610 | 666611 | 666612 | 666613 | 666614 | 666615 | 666616 | 666617 | 666618 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 100.00 |

**PLANOGRAPH**

**Top View**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | | 9 | | | 10 | | |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |

*10.1.7 Lamb Shank, layer pack*

RFID Product number 7777, SKU Number 83513

Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

| Run | 777701 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

| PLANOGRAPH |
|---|
| TOP View |
| 1 |

### *10.1.8 Lamb Bones, Bulk Pack*

RFID Product number 8888, SKU Number 84015

Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

| Run | 888801 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

PLANOGRAPH
TOP View
888801

*10.1.9 Lamb Leg Ch-off, Individually Wrapped, Vacuum Sealed*

RFID Product number 9999, SKU Number 87939

Piece Quantity 6, RFID Tag Quantity 6 **Result from 20 runs: 100% tag reads**

| Run | 999901 | 999902 | 999903 | 999904 | 999905 | 999906 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100.00 |

PLANOGRAPH

SIDE VIEW

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |

### *10.1.10 Lamb Breast, Bulk Pack*

RFID Product number AAAA, SKU Number 88601

Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

| Run | AAAA01 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

PLANOGRAPH
TOP View
1

*10.1.11 Lamb Leg Bones, Bulk pack*

RFID Product number BBBB, SKU Number 88675

Piece Quantity: Multiple, RFID Tag Quantity: 1 **Result from 20 runs: 100% tag reads**

| Run | BBBB01 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

PLANOGRAPH
TOP View
1

*10.1.12 Lamb Shoulder BRN Oyster, Individually Wrapped, Vacuum Sealed*

RFID Product number CCCC, SKU Number 87936

Piece Quantity: 12, RFID Tag Quantity: 12 **Result from 19 runs: 100% tag reads**

**Result from 1 run: 1 of 12 Tags not read, 92%**

| Run | CCCC01 | CCCC02 | CCCC03 | CCCC04 | CCCC05 | CCCC06 | CCCC07 | CCCC08 | CCCC09 | CCCC10 | CCCC11 | CCCC12 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 11 | 91.67 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | 100.00 |

PLANOGRAPH Unread RFID Tag

Side View

| | | | | | |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 9 | 8 | 7 |
| 4 | 5 | 6 | 10 | 11 | 12 |

*10.1.13 Lamb Rack, individually wrapped, vacuum sealed.*

RFID Product number DDDD, SKU Number 87931

Piece Quantity: 20, RFID Tag Quantity 20 **Result from 20 runs: 100% tag reads**

| Run | DDDD01 | DDDD02 | DDDD03 | DDDD04 | DDDD05 | DDDD06 | DDDD07 | DDDD08 | DDDD09 | DDDD10 | DDDD11 | DDDD12 | DDDD13 | DDDD14 | DDDD15 | DDDD16 | DDDD17 | DDDD18 | DDDD19 | DDDD20 | Tags Read | Tags Read % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 20 | 100.00 |

PLANOGRAPH

Side View (Ribs interlacing)

| | | | |
|---|---|---|---|
| | 1 | | |
| 2 | | | |
| | 3 | 12 | |
| 4 | | | 13 |
| | 5 | 14 | |
| 6 | | | 15 |
| | 7 | 16 | |
| 8 | | | 17 |
| | 10 | 18 | |
| 9 | | | 19 |
| | 11 | 20 | |

### *10.1.14 Lamb Neck, Layer Pack*

RFID Product number EEEE, SKU Number 85021

Piece Quantity: Multiple, RFID Tag Quantity 1 **Result from 20 runs: 100% tag reads**

| Run | EEEE01 | Tags Read | Tags Read % |
|---|---|---|---|
| 1 | 1 | 1 | 100.00 |
| 2 | 1 | 1 | 100.00 |
| 3 | 1 | 1 | 100.00 |
| 4 | 1 | 1 | 100.00 |
| 5 | 1 | 1 | 100.00 |
| 6 | 1 | 1 | 100.00 |
| 7 | 1 | 1 | 100.00 |
| 8 | 1 | 1 | 100.00 |
| 9 | 1 | 1 | 100.00 |
| 10 | 1 | 1 | 100.00 |
| 11 | 1 | 1 | 100.00 |
| 12 | 1 | 1 | 100.00 |
| 13 | 1 | 1 | 100.00 |
| 14 | 1 | 1 | 100.00 |
| 15 | 1 | 1 | 100.00 |
| 16 | 1 | 1 | 100.00 |
| 17 | 1 | 1 | 100.00 |
| 18 | 1 | 1 | 100.00 |
| 19 | 1 | 1 | 100.00 |
| 20 | 1 | 1 | 100.00 |

PLANOGRAPH
TOP View
1