RFID in Manufacturing and Distribution of Food: Livestock Industry

Alexander Hu
703369275
MAE 188
6/13/08

Introduction

In 2003, United States beef imports were banned by South Korea due to fear from Bovine Spongiform Encephalopathy, more commonly known as Mad-Cow Disease. However, on February 25, 2008 South Korea relaxed their restrictions on United States beef imports amid protests by South Koreans. Mad-Cow Disease, among other illnesses like Foot-and-mouth disease and Tuberculosis has prompted government organizations to implement cattle tracking systems in order to find infected animals quickly and prevent any further spreading. Historically, livestock branding identified ownership, but tracking through branding is an inefficient process that requires looking through every single cow. Radio frequency identification or RFID has been implemented in Australia as a national system to not only identify animals, but also keep electronic records of each. Though the US has not followed suit with a national system, the benefits of RFID in the livestock industry can be seen in Australia [1] [2].

ISO 11784

ISO (International Organization for Standardization) 11784 is the standard for the identification code in RFID tags for animals. The goal of ISO 11784 is so that an open standard is established and manufacturers can correspond to a set of specifications instead of each making their own. This was decided by going with a transponder-based standard versus a reader-based standard. A reader-based standard would have required manufactures to build readers capable of reading other manufactures' tags. With a transponder-based standard manufactures will all build tags with the same identification code so readers will naturally be compatible with other tags. The code consists of a 3 digit country code followed by a 12 digit national id code [3].

ISO 11784 is structured to allow for the recycling of numbers after 33 years, which exceeds the lifetime of most livestock animals. Though ISO 11784 was created for the livestock industry, tagging of small animals, exotics, and endangered species has also adopted the standard. This creates a problem, because while livestock won't surpass the 33 years, other animals live longer. Fortunately, there are more than enough combinations so even though the recycling numbers is allowed, trillion of numbers will need to be used before a repeat is issued. Still, there is no control over the numbers assigned so any problems arising will be due to simply different manufacturers or farms assigning the same number. In the United States, there is no national cattle tracking system so manufacturers may assign the same number but since the systems will be limited to within one farm, as long as there are no repeats there will be no problems [3].

In Europe, the Federation of European Companion Veterinary Associations has assigned the International Committee for Animal Recording to include manufacturer

codes to the 15 digit animal identification number (AIN), but this does not solve all the problems associated with it. Some tags are inserted under the skin or stomach and while those can be read without any issues, there is no visibility of the tag. This may result in faking the manufacturer code in order to deceive readers. Purebred pets can be mimicked for fraud, but the real danger is in the livestock industry. Bioterrorism can take place if the tag of a diseased animal is replaced by a fake tag and readers fail to recognize it [3].

ISO 11784/85

ISO 11785 specifies how information travels between the transponder and the receiver. The carrier frequency standard is 134.2 kHz which is of low frequency. The advantages of LF versus HF in the tracking of animals is that LF is better suited for single antenna systems, can read better through animal tissue, and is generally smaller for capsules that will be placed under the skin or in the stomach. These tags are passive and do not have a battery attached to them. Their only power supply comes from the signal sent from readers. The standard also allows for tags that are programmed once by the manufacturer or programmed after manufacturing. ISO 11785 also asks for readers to conform to two different types of information transfer approaches. The full-duplex or FDX approach is a simultaneous transfer of information. This approach utilizes a smoothing capacitor so the signal continues to be sent as long as the signal is maintained. The other approach is the half-duplex or HDX. HDX is different in that the signal from the tag is not sent until the storage capacitor reaches capacity and then sends only once. ISO 11785 calls for readers to be able to read both FDX and HDX tags [3].

HDX and FDX are inherently incompatible, but readers that are ISO-compliant are required to be able to read both. Though this is technologically possible, it is not economical to do so. FDX is also faster than HDX because of the constant signal, but that speed is negated with the reader having to be able to use both approaches. There are also no performance regulations so an ISO-compliant device does not necessarily mean it will work in a livestock farm because read ranges may be too poor for use [3].

ISO 11784 and ISO 11785 both work to standardize tagging in animals so multiple manufacturers can sell tags and little to no royalty fees will be paid. Though the standard allows for some variation in design, there is reason to believe that there is a little too much freedom, because certain designs are incompatible as well as performance differences. Despite these issues, national systems have been erected using these standards and they remain as the most popular for animal tracking [3].

Code Structure

Bit #	Information	Combinations
1	flag for animal (1) or non-animal (0) application	2
2-15	reserved field (reserved for future use)	16 834
16	flag indicating the existence of a datablock (1) or no data block (0)	2
17-26	ISO-3166 numeric-3 country code	1,024
27-64	national identification code	274 877 906 944

http://www.rfidnews.com/iso_11784.html

NAIS

The National Animal Identification System is a United States government program that seeks to limit the spread of animal disease by using identification. The system proposes a three step process. The first process is the premise identification

number which will assign each location with a number. The number will be linked to a national database which then has information for each premise, which may include the address, contact phone number, type of operation, and others. The second step is the animal identification step, which is assigning each animal with a unique identification number. This number will either be a 15-character AIN or a 13-character AIN. Like the premise number, this one will lead to a database with records of each animal. Finally, the last step is animal tracking. This is the creation of a database and protocol for updating the database through reports [4].

Though the NAIS has not specified the technology it will pursue in its proposed system, the United States Department of Agriculture (USDA) requires ISO 11784 and ISO 11785 standards [4].

The goal of the NAIS is to strengthen the US's disease response abilities, limit spreading of diseases, keep economic and animal losses at a minimum, protect farms, and maintain market access. If these steps are achieved, the NAIS wants to be able to full trace the origins of a diseased animal within 48 hours. Though the NAIS is still a work in progress, there are a total of 374,289 registered premises out of the 1,438,280 livestock farms in the US as of March 3, 2007 [4].

Michigan Animal Identification System

Even though the United States does not have a national livestock tracking system, there are moves to implement ones within a state. In Michigan, by March 1, 2007 all cattle of all ages have been mandated to be identified with a RFID ear tag. The Michigan animal identification system follows the NAIS guidelines of a three step identification.

The premises are given a seven-character designation while animals are given a 15-character designation, which follows ISO 11784 and ISO 11785 guidelines. The tags are required to be placed on the left ear of the animal [5].

NLIS

The National Livestock Identification System or NLIS is the first and largest national livestock RFID tracking system. The NLIS is based in Australia and utilizes Texas Instruments (TI-RFid) transponders which are ISO 1784/85 compliant. The NLIS mandates unalterable numbers that are one-time-programmable (OTP) and 16-characters. The Meat and Livestock Australia manages the databases for all the farms in Australia. AINs are not to be repeated and since there is a national system it is possible to mandate the uniqueness of each animal [6].

As each animal moves through the livestock chain, the data is scanned and updated into the database. The steps in the industry chain include producers, agents, saleyards, manufacturers and others [6].

The Australian government estimated the economic loss of a foot and mouth disease outbreak to be $2-13 billion US dollars. While the NLIS system is designed to tag and track every animal, it does not expect to prevent outbreaks, but to minimize any financial and social impact. This is important because Australia exports 70% of the meat production so there is a desire for credibility in the market. The NLIS RFID system has improved productivity, help mediate theft, and has also made it easier to integrate online abilities [7].

Allflex

The NLIS allows for many tag manufacturers as long as the tag conforms to ISO 11784/85 standards. One of the manufacturers is Allflex. Allflex offers both FDX and HDX tags that are ISO 11784/85 compliant. The Allflex HDX tag offers the highest performance in their lineup. The tags have the dimensions of 1.18 inches in diameter and 0.280 inches in thickness. The tag also weighs 8.9 grams. They are made of Polyurethane and plastic and are manufactured with the injection molding process. In addition to being ISO 11784/85 compliant, these tags are also ICAR and FCC approved. They are operational at temperatures of plus and minus 50 degrees Celsius. Allflex claims the tag to have a maximum of 100 centimeter read distance. These tags cost $2.35 each [8].

Allflex HDX tag

http://www.allflexusa.com/eid/half_duplex.php

The FDX tag offered by Allflex is smaller and lighter. The dimensions are 1.2 inches in diameter and 0.17 inches thick. The tag weighs 5.6 grams. Like the HDX tag, the FDX variant is made with injection molded Polyurethane and plastic. Also like the HDX tag, it is ISO 11784/85 compliant and ICAR and FCC approved. The operating

temperature is the same at plus or minus 50 degrees Celsius, but boasts a shorter maximum read range of 75 centimeters. The tag is cheaper at $2 each versus the $2.35 of the HDX tag [9].

AllFlex FDX tags

http://www.allflexusa.com/eid/full_duplex.php

Allflex also offers two different types of applicators to attach the tags onto animals. The Allflex Universal Total Tagger works for all their tags and costs $20. There is a $50.99 Ultra Retract-O-Matic applicator that retracts out of the air before the animal can react as a higher end applicator [10] [11].

Allflex Universal Total Tagger

Ultra Retract-O-Matic

http://www.allflexusa.com/eid/applicators.php

Stick readers by Allflex allow the user to read information on the tag by waving a stick in the vicinity of the tag. Allflex offers two different readers with one being a wired model and the other being wireless. The Allflex RS250 Series Stick Reader reads both HDX and FDX tags to fulfill the requirements of ISO 11785. The stick reader is constructed with fiberglass and plastic. 6 to 12 volt direct current external batteries can be used for this reader, but higher performance can be achieved with a higher voltage. The maximum read distance for a 6 volt configuration is 27 centimeters for a HDX tag and 20 centimeters for a FDX tag. Under a 12 volt configuration, the read distance jumps to 32 centimeters and 25 centimeters for the HDX and FDX tags, respectively. The reader is connected to a computer by the RS232 Serial Data Port through a coiled or straight cable. The read error rate is less than 1 in 10^{6} [12] [13].

The wireless reader offered by Allflex is the RS320. Like the wired version, the RS320 is constructed with fiberglass and plastic, but utilizes only a 9.6 volt direct current configuration. A rechargeable Nickel Metal Hydride or NiMH battery is used. The read ranges are 35 centimeters and 22 centimeters for HDX and FDX, respectively. This reader also utilizes a RS232 Serial Port to transfer data. Both of the readers use Configurator software to communicate with a computer, but can store over 3,000 transponder codes. This allows the readers to move freely before transferring data. The wired RS250 series costs $495 each while the wireless RS320 costs $850 each or $1,250 each for a Bluetooth enabled model.

Allflex RS250 Series Stick Reader

Allflex RS350 Series Stick Reader

http://www.allflexusa.com/eid/applicators.php

Panel readers are also available by Allflex. These panels are set upright next to gates so when animals pass through areas their tags can be read and their data can be updated. Allflex offers three different sizes, each with a different read distance. The PNL-2530-3 has the dimensions of 9.84” x 11.81” x 1.01” and has a maximum read distance of 60 centimeters. The PNL-4060-3 has the dimensions of 15.75” x 23.62” x 1.01” and a maximum read distance of 80 centimeters. The PNL-60120-3 has the dimensions of 23.62” x 47.24” x 1.01” and maximum read distance of 100 centimeters. The prices are $640, $775, and $830 each, respectively. They are made from ABS UL94 HB plastic [14].

Allflex Panel Readers

http://www.allflexusa.com/eid/readers.php

TekVet

Though ISO 11784 and ISO 11785 are the dominant standards for RFID in animals, there are other manufacturers who choose not to follow the standards and opt for an active system. TekVet, a company based in Florida has developed a system of active tags that can not only track the animals in real time, but also monitor each animal's temperature [15].

The TekVet TekSensor tag utilizes an active RFID system which gives it a battery attached to the tag. The frequency used is 418 MHz, which puts it at UHF. Each tag has a sensor that monitors the temperature and then relays the information back to the data center. TekVet uses TekReceivers which have a read range of 300 to 500 feet and are best used when placed at en elevated position overlooking the livestock. They can be solar powered as well. The readers can transmit data with cellular WAN network, satellite, DSL or microwave [16].

The TekVet TekSensor measures temperature with a thermistor, which reads the voltage based on the changing resistance due to temperature. The themistor goes into the

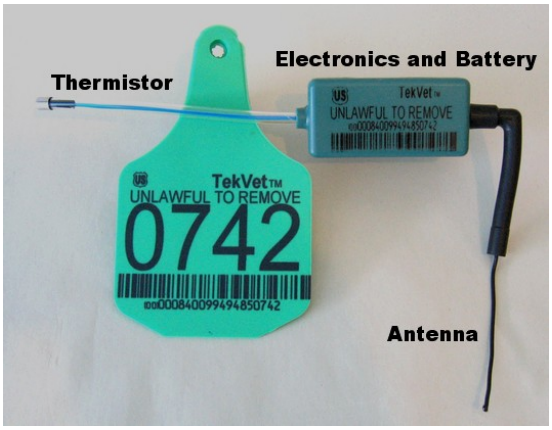
ear of the animal with the radio transmitter attached onto the outer parts of the ear. The thermistor constantly reads the temperature of the animal and the TekAccess software can alert of animals with temperature irregularities that may imply disease and also check the progress of recovering animals. TekSensor has clear advantages over an ISO 11784/85 compliant system because it is constantly relaying a signal back as well as having a much longer range. A passive tag would need to pass through certain readers in order for the cow to be read into the database but an active system is always on and cows should be able to be tracked anywhere it is as long as it is within the range of a receiver. Unfortunately, TekSensor will only find diseases like Bovine Respiratory Disease, Bovine Virus Diarrhea, Foot-and-Mouth Disease, and is not capable of tracking Mad Cow Disease because of the lack of temperature signs [16].

An analysis by TekVet shows that utilizing their product will not just find diseased animals, but it will increase profit. This report takes a farm with a 10,000 herd size or 10,000 cattle and analyzes the differences of using a TekVet system versus nothing at all. First, TekVet assumes that prime grade will sell for $92, choice for $88, select for $83, and cut for $60 per hundred pounds. TekVet claims a 50% reduction in loss due to illness and a 20% reduction in treatments given. Their estimate states that 100 less animals will be lost and 2,000 less treatments will be given. TekVet also states that there will be more prime and choice grade cattle due to the better quality. This will result in an increased sales of $198,757. In addition to this bonus, $30,000 will be saved from reduced treatment costs, $216,110 from improved weight gain, $108,055 from increased premium at action, and $3,000 from reduced labor expenses. All of these savings put the TekVet system at a gross increase in profit of $555,922. Of course, the estimated

expenditure for the TekVet system for 10,000 animals is set at $200,000 so the final increase in profit will be $355,922 [16].

Profit is an important factor in choosing the TekVet TekSensor tags, but in addition to making more money, the benefits include simply digitalizing the whole farm. TekVet allows for owners of cattle farms to be able to look at their data from across the globe due to the integration of the internet with the system. Most diseased cattle do not show major visual signs until 48 hours after core temperature changes so having TekSensor tags in each animal can be a very helpful in diagnosing early [16].

TekSensor Tag



TekSensor Tag Placement

http://www.tekvet.com/_mgxroot/page_10745.html

Cowcatcher II

In May 2007, the Department of Agriculture, Fisheries and Forestry in Australia tested the NLIS system. They called this test Cowcatcher II. The objective of this test was to evaluate the tracing system of livestock, identify needs for improvement. The tested areas were Foot and Mouth Disease susceptible livestock. The test began at 9am on May 1, 2007 and ended at 12pm May 3, 2007. The participants in the exercise acted

as if there were a disease outbreak so there would be a sense of urgency and the best possible time can be achieved [17].

There were several tracing issues involved in the test. The first were a number of IT failures because many farms did not technical backup to overcome IT failures. There were also a lack of staff on hand to maximize the tracking response time. It is assumed that speeds could have been even faster with a more available staff. Since the test was a national exercise, there were different jurisdictions and it was often that each had a different format. Each farm was required to submit a report and the reports often had different formats and different types of data due to the different requirements of each jurisdiction. Some jurisdictions also had the equivalent of a local disease control center and they had a better response to the test than farms without one [17].

The success rate of Cowcatcher II was that 96.7% of the animals were traced back to their property of birth within 24 hours and the rest were tracked in 48 hours. Though all were eventually traced, the test was to meet the National Traceability Performance Standards. The requirements of the NTPS is that within 24 hours the possible locations of where the animal has been the previous 30 days must be identified as well as any susceptible animals in contact with that animal. In 48 hours, all of the animal's resident locations must be identified as well as the rest of the susceptible animals in contact. All the animals were tracked to their origin of birth after 48 hours, but finding the susceptible animals in contact did not fully complete. Four of the animals failed to be fully traced and verified within 48 hours [17].

Despite these issues, the consensus of Cowcatcher II is that it was a success and it met all the objectives of evaluating the tracing systems of livestock in Australia. Even

with the four animals that didn't meet the deadline, the 98.7% success rate demolished the 75% success rate of the first Cowcatcher exercise. Improvements were noted and are in the process of implementation [17].

Conclusion

In an industry that has been around for centuries, many old habits are hard to break. Branding has always been used and is still a valid sign of ownership. The emerging use of RFID in livestock not only helps prevent the spread of diseases, it also streamlines the process of cattle to meat industry by eliminating paperwork and making everything electronic. A RFID system also decreases the amount of workers needed because of the automation of collecting data as the cows move the gates. Overall, money can be saved by implementing RFID into a livestock farm. Though these systems have these benefits, in a normally old fashioned business it is vital to update it to the internet age to keep up with the rest of the world. With Australia's NLIS and TekVet's TekSensor tags, there are a multitude of technologies available. Whether it is active, passive, HF, LF, the advantages of a RFID system is there and tests like Cowcatcher II show that even the low tech ISO 11784/85 compliant systems can be very successful. Ultimately, disease prevention will end up being the sole reason national tracing systems are implemented and consumers all over the world will benefit from RFID.

References

1. “SKorea Cabinet offers to resign over beef imports.” Google News. 9 June 2008.
<http://ap.google.com/article/ALeqM5gliEd1Bi_qB68ysYSDK2b_vze2ygD916VLK80>.

2. “READING AND UNDERSTANDING LIVESTOCK BRANDS.” Livestock brands. 1 June 2008 <http://www.cowboyshowcase.com/brands.htm>

3. “ISO 11784/85 "STANDARD" WITH BLEMISH.” RFID News. 15 November 2004. <http://www.rfidnews.com/iso_11784.html>

4. “National Animal Identification System (NAIS).” 11 June 2008. <http://animalid.aphis.usda.gov/nais/>

5. “Michigan Animal ID System 3 21 07.” Michigan Animal ID. 21 March 2007. <http://www.michigananimalid.com/Michigan_Animal_ID_System_3_21_07.ppt>

6. “RFID for Livestock and Animal Identification.” Radio Frequency Identification. 11 May 2008. <http://www.electrocom.com.au/rfid_animalid.htm>

7. “NLIS Advantages.” National Livestock Identification System. 14 February 2008. <http://www.mla.com.au/TopicHierarchy/IndustryPrograms/NationalLivestockIdentificationSystem/NLIS+Advantages.htm>

8. “HDX High Performance Ultra EID Tag.” Allflex. 2006. <http://www.allflexusa.com/pdfs/EID_HDX_Ultra_Tag-V6.pdf>

9. “Universal Total Tagger Applicator.” Allflex. 2006. <http://www.allflexusa.com/pdfs/Universal_Total_Tagger_V6.pdf>

10. “Ultra Retract-O-Matic for EID Tags.” Allflex. 2006 <http://www.allflexusa.com/pdfs/Ultra_Retractomatic_V6.pdf>

11. “RS250 Series Stick Reader ISO Compatible.” Allflex. 2006. <http://www.allflexusa.com/pdfs/RS250SeriesStickReader.pdf>

12. “RS320 Series Stick Reader ISO Compatible.” Allflex. 2006. <http://www.allflexusa.com/pdfs/Revised_RS320SeriesStickReaderDetailer.pdf>

13. “PNL Series Panel Readers ISO Compatible.” Allflex. 2006. <http://www.allflexusa.com/pdfs/SeriesPanelReader.pdf>

14. “TekVet-IBM Cattle Tracker Uses Active RFID Tags, Satellite Communication.” RFiD Journal. 24 August 2006. <http://www.rfidjournal.com/article/view/2612/>

15. “Installation of the TekVet tag in livestock.” TekVet Technologies. 2008. <http://www.tekvet.com/_mgxroot/page_10744.html>

16. “Benefit Analysis for the TekVet Health Monitoring System.” 2008. <http://www.tekvet.com/_mgxroot/page_10755.html>

17. “Exercise Cowcatcher II.” DAFF. May 2007. <http://www.daff.gov.au/__data/assets/pdf_file/0019/324181/cowcatcher2-report.pdf>