MRC Project M.796

Technical Report on the Development of the MeatSCAN 150T

for
Milestone 6

Prepared by:
Dr J Asbury
22 June 1998

Project Summary

Research work conducted by the IGNS in New Zealand, resulted in a technology that could determine the fat content of meat with the aid of nucleonic techniques. The aim of this project was to develop the conceptual prototype into a commercially available gauge that could be utilised in a harsh abattoir environment. As discussed in this report the cost/accuracy trade-off had to be thoroughly investigated in order to develop a resultant gauge that could produce acceptable accuracy at an affordable cost. This project addressed this problem by using modelling techniques to optimise the componentry for the desired gauge precision. Additionally, development work included mechanical and electrical design as well as electronic and software design and development. Scantech's expertise in this field resulted in an effective instrument design and ultimately its prototype construction.

Activities of the Project

The purpose of the commercialisation of the MeatSCAN (Phoebe) technology was to design a product which would be acceptable to the industry in terms of the following criteria:

- Price
- Measurement performance
- Safety
- Reliability
- Compliance with industry regulations

It is believed that all these requirements have been satisfactorily addressed.

The hardest decisions had to be made in area of price and measurement performance. Due to the high price of liquid scintillation detectors and nuclear electronics it was designed to compromise the performance somewhat in order to achieve the required selling price. The compromise in performance is not great and it does not significantly affect the usefulness of the MeatSCAN 150T to the industry.

A higher performance (and higher cost) MeatSCAN could be introduced in the future if there is demand from the industry.

Nuclear Modelling of the Measurement Geometry

Monte Carlo modelling of the measurement geometry was conducted using the MCNP code. This allowed the design to be optimised to minimise unwanted radiation arriving at the detector. Unwanted radiation consists of neutrons and gamma rays which have scattered from the structure of the analyser and which do not contain any information about the composition of the meat. Minimisation of unwanted radiation allows significant improvement in measurement precision. The unwanted radiation increases the detector count rate and adds uncertainty or noise in the measurement. If the unwanted radiation is reduced the source size may be increased to further improve precision.

Another important design decision was the choice of size and number of liquid scintillation detectors. Each detector has a maximum count rate and the use of multiple detectors allows an increase in the total count rate to be achieved. A higher count rate allows a better measurement precision in a given measurement time.

Rectangular detectors were used in the MIRINZ Prototype. These however, turned out to be prohibitively expensive. There was also a question about their long term reliability. The manufacturer (Bicron) were said to have had trouble adequately sealing rectangular detectors.

The decision was made to use a single 200mm diameter by 165mm deep scintillation detector.

Nuclear Testing on Alpha Unit (supplied by MIRINZ)

The detectors and electronics from the MIRINZ prototype were supplied to Scantech in Adelaide for testing. The system was set up to record gamma and neutron fluxes from a neutron source belonging to Scantech.

Four ground meat samples covering a range of approximately 50 to 90 %CL were prepared. A representative sub sample was taken from each sample and these were analysed using the soxhlet method. The remainder was frozen into a cylinder of diameter 200 mm. This size is the internal diameter of the sample tube used in the MeatSCAN.

These samples were used to obtain a preliminary calibration using the MIRINZ hardware. They were later used to determine a calibration for the MeatSCAN 150T.

Nuclear Electronics

High detector count rates are essential for good measurement precision. This was achieved in the MIRINZ Prototype by the use of an Oxford Instruments model TC 5020 PSD module. This electronics module is no longer manufactured and an alternative had to be found.

Initially work was done on developing specialised electronics to replace the commercial electronics used in the MIRINZ prototype. However, this proved to be prohibitively expensive and an alternative to the Oxford TC 5020 was sought. The FAST ComTec model 2160A PSD module was found. This would not handle as high a count rate as the TC 5020. However, with the improvements in the measurement geometry it was determined that the count rate was adequate.

The nuclear electronics (nucleonics) used in the MeatSCAN is now based on commercially available nucleonics modules. The most appropriate and cost effective modules had to be selected from the wide range currently available. These module are installed in an electronics rack which processes the electronic pulses produced by the detector. The following functions are provided:

- High Voltage supply to the detector under software control

- Pulse Shape Discrimination (PSD) to separate neutron pulses from gamma ray pulses
- Pulse height analysis to provide count rates for gain stabilisation
- A counting system, with an interface to send data to the computer

A new method of gain stabilisation was developed for the MeatSCAN 150T. This uses a peak in the gamma ray pulse height spectrum caused by neutron capture by hydrogen. This method is simpler than the TESS system that was proposed for the MIRINZ system.

Mechanical Design and Development

The MeatSCAN was designed to meet the requirements of the Australian code of practice for the safe use of radiation gauges (ref. 1). This document specifies maximum radiation limits in the vicinity of the gauge and specifies that the structure of the gauge be resistant to mechanical damage and fire. Specially formulated fire resistant neutron shielding material is used inside the MeatSCAN. Scantech has designed many gauges to meet the requirements of this code and has obtained approval for the use of these gauges in Australia and overseas.

Initial layout drawings of the MeatSCAN were started once the electronic components had been finalised. It was important to get the correct layout of the source / collimator / sample tube / detector to ensure good performance from the gauge. Weekly design review meetings were held and once the overall layout was finalised other key areas were reviewed in detail.

The design of the source rod assembly required that the source could be retracted into a "beam off" position and have an external indication of whether the beam was on or off. The ability to lock the source in the retracted position was required by authorities.

The detector assembly involved mounting one large detector with shielding as an assembly which could slide into position with a positive lock. The size and type of shielding was determined by modelling. The detector assembly needed to be in its own heated area (30 deg C).

All external surfaces of the MeatSCAN are constructed from 316 grade stainless steel and the cabinet may be hosed for cleaning. The electronics cabinet need to be insulated and waterproof, whilst no heater was required an anti-condensation heater was fitted. The cabinet size and layout were developed to accommodate the other functions of the machine.

Electrical Design and Development

Initial discussions were undertaken between the Engineers and Scientists to determine the overall requirements. These requirements were related to:

- Required interfaces to plant
- Required control from the computer
- Required interface from the computer

- Temperature control of the nucleonics
- Power supply and its quality

Once the guidelines for this design and layout were defined further discussions were held with the Mechanical Design Department pertaining to mechanical limitations and size of the final electrical panel. Finally the electrical layout and specification was written incorporating the Australian Wiring Standards AS3000.

Some of the MeatSCAN Electrical System components include an uninterruptable power supply for the computer and a thermostatically controlled heater for the detector. A discrete input/output module allows the connection of control signals to and from the plant.

Software Design and Development

The MeatSCAN 150T contains an IBM compatible system running Microsoft Windows NT 4. Software has been written for this computer to provide the following functions;

- Reading of count rates from the Electronics Rack
- Gain stabilisation and control of HV
- Processing of count rate data to calculate %Fat in Meat
- Storage and editing of configuration parameters
- Storing results in a database
- Making results available over a network
- Interfacing to plant via serial data links
- Access via telephone line and Modem (if required)

Prototype Commissioning and Testing

The assembled MeatSCAN 150T has undergone a series of tests in the factory at Scantech. These simulated the operation of the MeatSCAN in a plant. A calibration was derived using the four frozen meat samples. Stability of the calibration was checked using a paraffin wax standard. This had similar neutron and gamma rays absorption properties to meat, but it could be left in the MeatSCAN for several weeks to assess the long term stability of the counting system.

During stability testing the software tools for modifying parameters and transferring data over a computer network were used.

A radiation survey around the MeatSCAN has also been conducted. This information is required to obtain approval to supply a MeatSCAN to a meat processing plant.

Conclusion

Milestones 4, 5 and 6 have been completed. A commercial prototype has been assembled and tested in the factory at Scantech. A factory demonstration was held at Scantech on 29 May 1998 where the capabilities of the unit were demonstrated. Meat samples were placed in the unit and results of the measured % CL content of the meat were displayed. A specification booklet and brochure were made available at the demonstration (the brochure is attached herein and the specification booklet has already been submitted by Vomax). The simulation model was demonstrated to the industry and this demonstrated the fundamental need for the MeatSCAN gauge for the total process system.

This document details the activities undertaken for the project and the resultant findings and recommendations. The brochure, photographs and drawings are included herein for reference purposes. The need for a video is seen as inappropriate at this stage as the effectiveness of the system can only be demonstrated once the total "Beast to Box" system has been fully installed and is functioning in a factory environment. A summary report suitable for distribution to the industry has already been submitted by Vomax detailing the total "Beast to Box" system.

It is perceived that although this project has been a success in effecting the modelling and commercialisation of a nucleonic gauge for measuring the chemical lean content in meat, the total project will have its main influence within the total "Beast to Box" system. To this end the total system needs to be fully installed and tested within a factory packing environment. This total system concept does require further effort in its development as well as the remaining unforeseen obstacles that are to be encountered during its implementation.

Acknowledgments for this Report:
K. Smith, T. Barratt, P. Busby

References

1. National Health and Medical Research Council, Australian Government Publishing Service, Canberra 1983,"*Code of Practice for The Safe Use of Radiation Gauges*", ISBN 0 644 05541 3