

# Features of a new calorimetry unit to measure heat production and net energy by group-housed pigs

C.J. Muñoz, T.L. Funk and H.H. Stein\*

Department of Animal Sciences, University of Illinois, Urbana, IL, USA; hstein@illinois.edu

## Abstract

The Swine Calorimeter Unit (SCU) has been constructed at the University of Illinois at Urbana-Champaign. The objective of the SCU is to be able to determine net energy (NE) of diets and ingredients fed on an ad-libitum basis to group-housed pigs in all phases of production. The SCU allows for calculating NE based on the indirect calorimetry procedure. There are 6 calorimetry chambers in the SCU. Each chamber is made air-tight, and measures 1.8×2.0×2.7 m, has fully slatted floors, and a volume of 10.2 m<sup>3</sup>, with a capacity to hold 4 to 10 growing-finishing pigs depending on size. There are 4 manure screens and 2 urine pans under the slatted floors. Each chamber is equipped with a fresh air supply system. A regulator unit controls humidity and temperature in each chamber. The 'classic line system' developed by Sable Systems International is used to measure gas exchanges in the chambers. Methane, carbon dioxide, and oxygen gases are measured in a determined period and are reported in percentage units. The initial objectives include comparisons of net energy in individually housed and group-housed pigs.

**Keywords:** calorimeter, group housing, net energy

## Description of the swine calorimeter unit structure

The swine calorimeter unit (SCU) is located at the Swine Research Center at the University of Illinois at Urbana-Champaign. The unit is a wood frame construction on a steel chassis, with oriented strand board walls, a wood truss roof, and a plywood floor. All surfaces on the inside are coated with sprayed-on plastic for water-tightness. The unit consists of a feed storage room, an access corridor, 3 equipment rooms, 6 calorimeter chambers, a computer room, and a mechanical room (Figure 1). The feed storage room is temperature- and humidity controlled to avoid spoilage of feed. The air handling and gas analyzing equipment for each chamber is located in the 3 equipment rooms and includes systems to control fresh air supply to the chambers, equipment to control temperature and relative humidity inside the chambers, and equipment to analyze air samples for oxygen, methane, and carbon dioxide. All equipment is wire-connected to the master computer, which is located in the computer room. This allows for real-time monitoring of all equipment and monitoring of the well-being of animals in the chambers. The mechanical room is where utility entrances are located.

## Description of the chamber structure

Each chamber is composed of the main chamber for animals and a secondary chamber to collect feces and urine underneath the main chamber. The main chamber has a volume of 6.5 m<sup>3</sup>. The doors

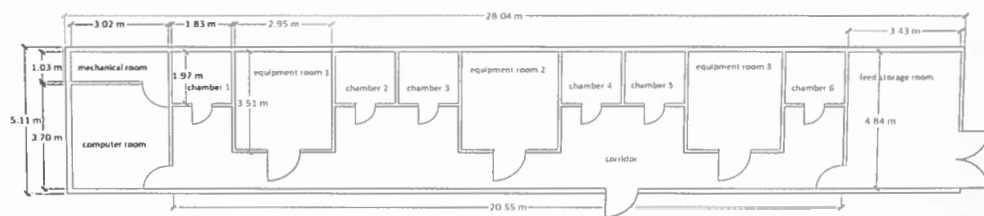


Figure 1. Plan of the swine calorimeter unit.

of the chambers are air-tight by means of a gasketed surface and have rubber-metal handles for complete closing. The secondary chamber has a volume of 3.1 m<sup>3</sup>. The floors in the chambers are galvanized steel modular slotted floors with the animal contact surface made of a series of spaced triangular bars. The air supply duct and diffuser, which provides the air exchange needed to hold 4 to 10 growing-finishing pigs, is located in the ceiling of each chamber. The secondary chamber has 4 flat stainless steel wire screens and 2 pans for feces and urine collection, respectively.

### **The parameter generation and control<sup>®</sup> unit (PGC)**

Attached to the calorimetry chamber is the PGC unit (PARAMETER, Black Mountain, NC, USA). There are two PGC units in each equipment room, controls humidity and temperature in a single chamber via flexible air ducts. The precision for maintenance of the temperature can be controlled with an accuracy of  $\pm 0.1$  °C and relative humidity is controlled within a range of  $\pm 0.5\%$ . This level of precision is ensured by the use of the dew point control system. The PGC air handler contains a blower rated at 700-1,100 m<sup>3</sup> of air per hour. The rated maximum heat of rejection for each unit is approximately 7,300 W per hour.

### **Fresh air intake and air exchange system**

Two air supply systems are placed in each equipment room. These systems provide clean air for the air exchange into the chambers and provide the baseline needed for the gas analyzer. The fresh air intake and air exchange system consists of a centrifugal inline fan (Fantech, Lenexa, KS, USA), which has a maximum rated airflow of 293 m<sup>3</sup> per hour. The AccuValve<sup>®</sup> (ACCUTROL LLC, Monroe, CT, USA) is also part of the system. A controller modulates the blades inside the AccuValve<sup>®</sup> to achieve the airflow determined in the set point and moderates the airflow to enter each calorimeter chamber. The air exchange in the chamber is also controlled by the AccuValve, and chamber pressure is regulated by a manual rotary plate valve located in the exhaust duct, which allows chamber air to vent to the outside of the building.

### **Gas analyzers**

There are 3 gas analyzer systems located in the 3 equipment rooms. The analyzers are the 'classic line' developed by Sable Systems International (SABLE SYSTEM INT., Las Vegas, NV). Each system analyzes air from 2 calorimeter chambers, and consist of 2 pumps, a multiplexer, a sub-sampler, a humidity sensor, an oxygen analyzer, a carbon dioxide analyzer, and a methane analyzer. The air subsample first enters the methane analyzer, then the carbon dioxide analyzer, and as the last step the oxygen analyzer. The gas analyzers provide readings in percentage units with high resolution. Those values are obtained in a determined period to enable calculation of total heat production from each chamber.

### **Conclusion**

The SCU has been constructed to determine net energy (NE) in diets and ingredients fed to pigs, to compare NE values between individually housed and group-housed pigs, and to investigate effects of feed additives and feed processing on NE.